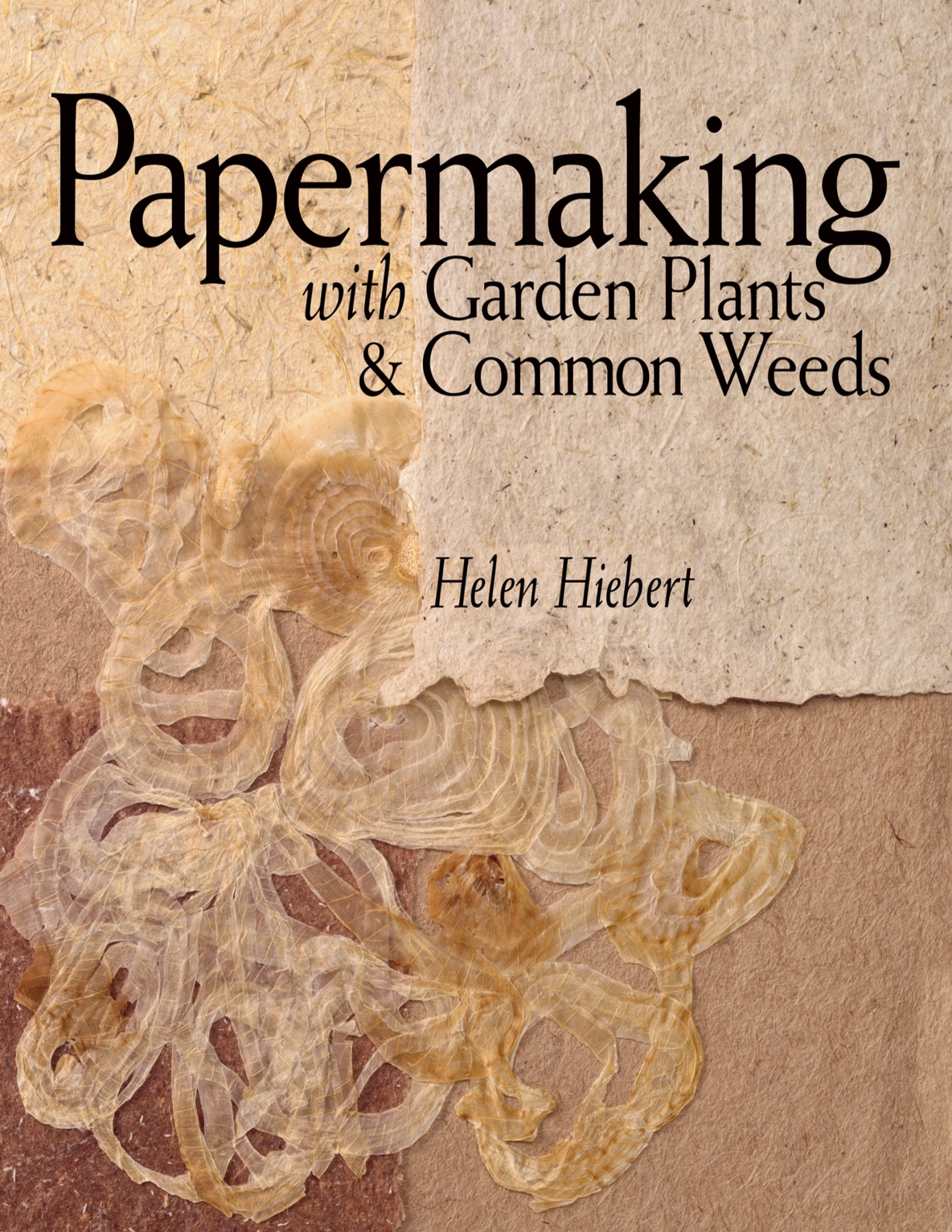
Papermaking

with Garden Plants & Common Weeds

Helen Hiebert



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Papermaking
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Helen Hiebert

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Share Your Experience!

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PREFACE

I have always enjoyed working with my hands and creating things. As a child, I spent hours drawing and doodling. My parents encouraged my creativity, sending me to various arts and crafts activities, even hiring their artist friends to give me lessons. I treasure that they fostered the artist in me.

I became interested in paper when I was studying at the University of Mainz in Germany for a year and took a course titled "Paper," in which we cut, folded, layered, built, and sculpted with paper. A few years later, on a brief trip to Japan, I noticed handmade paper for the first time and decided to learn how to make it. I began in my kitchen with a blender and junk mail. I soon graduated to incorporating plant parts as decorative material — leek stalks, onion skins, flower petals. The process was enthralling and I began researching ways to return to Japan to study papermaking with the masters.

I was living in Brooklyn at the time, and little did I know there was a hand papermill right next door, in Manhattan! But I soon found Dieu Donné Papermill and became an intern, sweeping the floors, changing the cloths between the sheets of paper as they dried, cutting rags, and absorbing as much information as I could about papermaking. I was fortunate enough to be in the right place at the right time — the mill was expanding and I was hired on staff. I continued my experiments with papermaking and became interested in plant

fibers — and soon I learned how to make paper literally from the ground up.

I am grateful to the many experts in this field who have taught and guided me through this process, both those I have worked with and learned from, and those I have never met. They are passing on an important tradition while breaking ground, developing new techniques, and reinventing old ones. Although I have spent the past seven years learning about handmade paper, I feel as though my journey into papermaking has just begun. There are so many subtleties — and that is what makes it so exciting to me. There is always something new to learn, lots of little adventures to take, a discovery to be made. Now it is my turn to share some of my knowledge with you and set you on your way.

Introduction

Papermaking is a craft whose ancient methodology and techniques, developed almost 2,000 years ago, still guide the ways in which paper is made today. Ts'ai Lun, an emperor's eunuch in China, is often credited with paper's invention in the year a.d. 105. This papermaking process was promoted and refined as it spread across the world and centuries later, in 1798, the first papermaking machine was invented in France by Nicholas Louis Robert. The machine was perfected in England in the early 1800s by the Foudrinier brothers, and as its speed and efficiency became apparent, hand papermaking became an old-fashioned and cumbersome method for making paper. Today, modern papermaking machines mass-produce paper in amazing quantities, but still use the same principles developed by our early ancestors.

In the first part of the 20th century, Dard Hunter, a researcher and historian, revived the craft of hand papermaking and eventually set up a mill in Connecticut for the small-scale production of paper with which to print his books about papermaking. Hunter traveled extensively around the world studying historical and contemporary papermaking practices and building a comprehensive collection of papermaking tools and paper samples. His collections and archive are currently housed by the Robert C. Williams American Museum of Papermaking in Atlanta, Georgia.

In contrast to Hunter's interest in history and books, other artists became interested in handmade paper as an art

medium. These artists began painting and sculpting with paper pulp, and making custom sheets for their prints. Papermaking programs were founded at various colleges and universities as artists began sharing their discoveries. In the 1970s, several small hand papermills formed, focusing on making paper for artists and on creating art from handmade paper. Today, many mills dedicate themselves to research, studying ancient techniques and adapting them to meet contemporary needs. By offering apprenticeship and internship programs, these mills are passing on knowledge of an age-old tradition.

Paper's possibilities are endless, and there is heightened interest today in making paper from plants, which are plentiful, easy to harvest, and require little equipment to process. Professional papermakers and entrepreneurs around the world are using handmade paper made from common plant fibers to develop new products in the form of stationery, books, lamps, and jewelry in addition to simply selling unique handmade sheets. Economic development projects have sprung up around the world as environmentally friendly methods of producing paper are sought. Papermaking has become so popular that children now regularly learn how to make it in school.

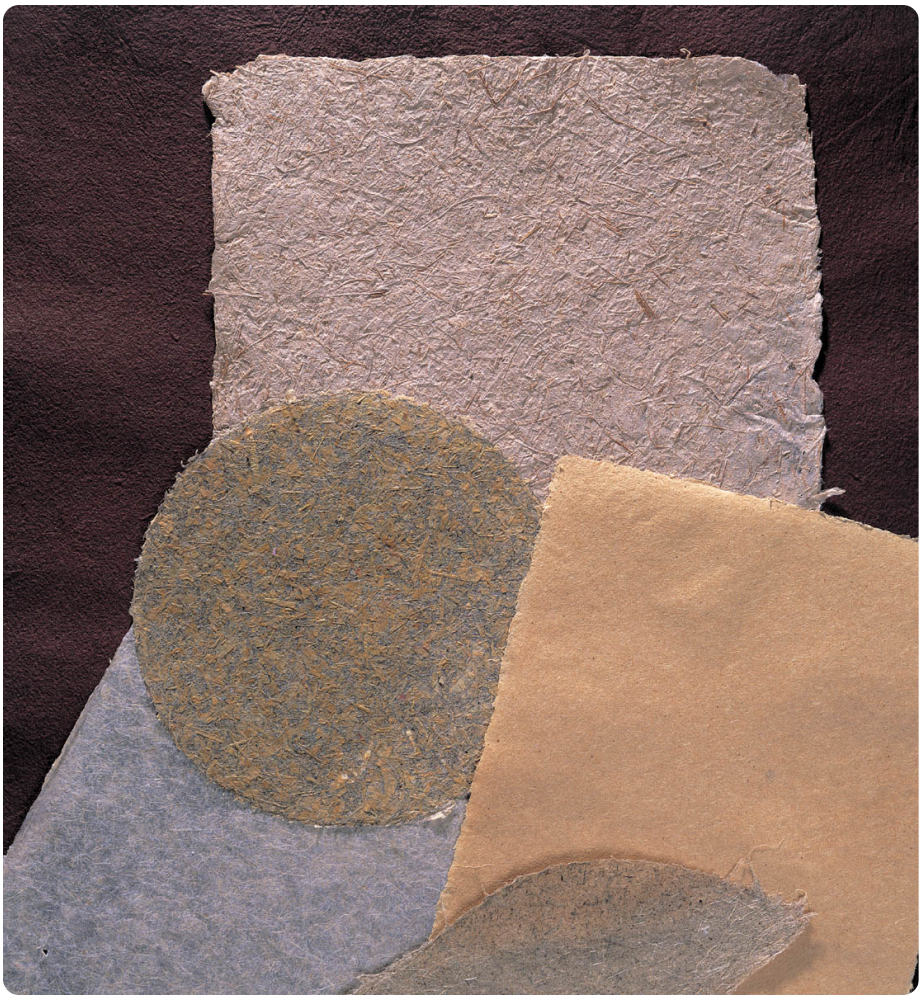
With a few basic pieces of equipment and some garden clippings or prunings, you, too, can make paper. As you go through the different stages of processing your plants, I hope you will gain a new respect for this ancient tradition, as well as a wonderful sense of discovery and creation that sparks a tingle of joy.

ABOVE: *In addition to creating unique handmade sheets, papermakers shape, cast, and rework the surface of their papers to craft a wide variety of beautiful products.*

CHAPTER 1

Collecting Plant Fiber

You do not have to go farther than your own backyard or neighborhood to find a number of plants suitable for papermaking. Many common garden plant parts make lovely papers, such as the leaves of irises, gladioli, and daylilies, the stems of okra and hollyhocks, and the stalks of corn. Even in your kitchen compost, you can find papermaking plant parts such as onion skins, artichoke leaves, and corn husks. If you do not have a backyard — I don't, I live in an apartment in New York City — there are many other places to find papermaking plants. I collect onion skins from the bottom of the bin at the local grocery store, for instance, and get corn husks at the neighborhood farmer's market. Nurseries and flower shops often have plant waste lying around, and roadside weeds such as cattails and phragmites are abundant and suitable for papermaking. Be creative — the possibilities are endless.



Fiber in the Field

Fiber is a major component of papermaking plants, providing elasticity, flexibility, and tensile strength. Fibrous plants have been used for ages to make items such as cloth, rope, baskets, mats, and brushes. These plants can also be used to make paper, and they will often suffice as the sole ingredient in your sheets of paper.

As you venture out into your garden or the wilderness, keep an eye out for plants that might be suitable for papermaking. Experiment, do some research, or ask an expert to help you find plants that you can turn into handmade paper.

Safety

When you're foraging for plants, be aware that some are poisonous. If you familiarize yourself with their appearance before you go into the field, they will be easy to avoid. Poison ivy, poison oak, and poison sumac are common plants that can cause skin irritations and allergic reactions. To protect yourself from inadvertent exposure, wear long pants, long sleeves, and gloves. It's also a good idea to change your clothes and rinse off when you return from collecting.

Environmental Awareness

Respect the property of others. Many wild or overgrown places may seem inviting to forage, but you might not be welcome there; get permission before gathering plants from private property or public parks. If you ask, you might even get help. Friends of mine are so intrigued that I make paper from plants that they save their gladiolus and daylily leaves for me. Landowners will most likely be curious and maybe even grateful that you want to make paper out of their annoying weeds.

In addition to being sensitive to the people who own or tend the land, it is important to be sensitive to the life of the plants.

While you're getting permission to forage, you may be surprised to find that picking a certain plant will disturb a natural ecosystem, create erosion problems, or interrupt the life cycles of insects or animals. For example, during late summer and early fall, monarch caterpillars form their cocoons and feed on the milkweed plant. By simply delaying your harvest for a few weeks, you can avoid disrupting their habitat.

In some cases, the plant you want might be endangered or near extinction. It often takes a lot of plant material to make a few sheets of paper, so in the case of a struggling species, your harvest may not leave enough plants for the particular population to recover. As a rule of thumb, ask before you pick.

Equipment

There are a few simple tools you need to collect papermaking plants. Take a pencil and a notebook along for notes, and a camera if you wish to make visual documentation. A jackknife or a pair of hand pruners will be useful for cutting stems and branches. Don't forget to bring a knapsack, bag, or string to tie up your cuttings and carry them home. Bring a pair of gloves to protect your hands from scrapes and scratches. If you plan to wade into a swampy area to collect grasses, it's a good idea to wear waterproof boots.

ABOVE: *If you are a gardener, you will probably have all the equipment you need in your shed.*

How to Find Papermaking Plants

- **Take a walk.** Vacant lots, roadsides, riverbeds, swamps, gardens, farms, and train tracks are just a few locations in which you might find papermaking plants.
- **Do some creative research.** Historical accounts of how people have used plants for papermaking and other crafts can be found in books on papermaking, textiles, and

basketry. Early Chinese papermakers used hemp, fishnets, tree bark, and old rags for their fiber. Native Americans used tule *(Scirpus validus)*, a soft-stemmed bulrush, to make mats, baskets, walls, and roofs. The bast of the lime tree (*Tilia* spp.) was used to make shoes and brushes in Russia. All of these materials and many others make fine paper.

- **Study a field guide.** Although at first glance botanical nomenclature may appear baffling, it can help you focus your search for fibers and locate what grows in your region. Plants in the same botanical family often have similar physical characteristics, so by paying attention to botanical orders and plant family names, you can identify potential papermaking plants. For example, paper mulberry, also known as kozo, which is one of the predominant papermaking fibers in Japan and also grows throughout the United States, is in the Moraceae family. True hemp *(Cannabis sativa)* and breadfruit *(Artocarpus altilis)*, other members of the Moraceae family, are also good papermaking plants.
- **Study papermaking manuals.** There are a few books that provide lists of papermaking plants and paper recipes. *Plant Fibers for Papermaking*, by Lilian Bell, is an excellent guide to over 80 plant fibers, and Winifred Lutz's appendix in *Japanese Papermaking*, by Timothy Barrett, also contains recipes and detailed information for making Japanese-style paper with North American plant fibers (see Reading List).
- **Take a class.** There are a number of papermakers working with plant fibers who teach at art centers. Papermaking courses are also offered at some colleges and universities.

- **Ask an expert.** If you have trouble identifying or locating a particular plant, call a local botanist or horticulturist. You can find these experts at local colleges or university extension services, plant nurseries, botanical gardens, or horticultural societies.

Harvesting

In general, harvesting at the end of the growing season will yield the most papermaking fiber, but there are a few other things to consider. For instance, you might want to let the plant naturally decompose in the field to make processing easier (see Retting). In addition, most fibers can be harvested during more than one season, and paper made from fiber harvested in one season may look different from paper made from the same fiber harvested in a different season. For example, young nettles (*Urtica* spp.) harvested in spring make a green paper, but if they are harvested in fall the resulting paper is brown. The age of the plant, soil, and environmental conditions such as air quality and rainfall will also affect the fiber quality and the look of your final sheet. Experiment with different seasons and locations, and keep records of your harvesting and paper results.

Plant Names

Botanical names are the standard way to identify plants. A botanical name usually consists of two Latin words. The

first designates the genus (a group of plants with a distinctive set of similar characteristics) to which the plant belongs. The second denotes the plant's species (a smaller, even more similar group within the genus). The species name may refer to the place of origin or one outstanding characteristic of the plants in that group. For example, the Latin name for flax is *Linum usitatissimum*. *Linum* indicates that it belongs to the genus Linum, and *usitatissimum*, its species name, means "most useful."

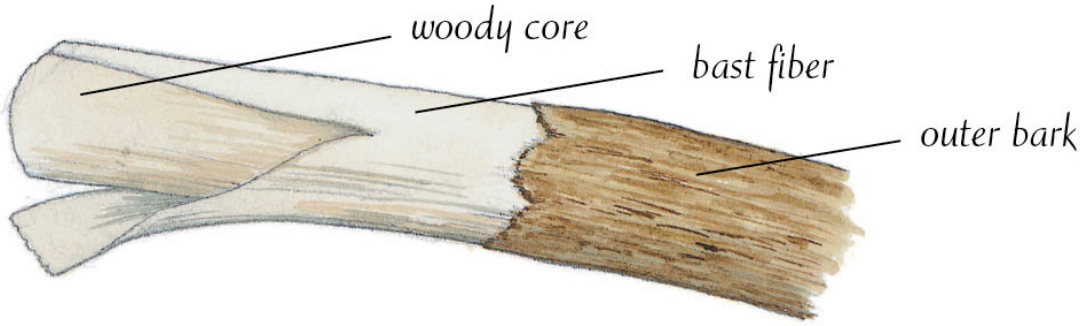
Papermaking Fibers

There are three main types of plant fiber used in papermaking: bast (inner bark) fiber, leaf fiber, and grass fiber. Papermaking Plants, a guide to plants in each category, will help you get started, but its list is by no means exhaustive. From other papermakers, books on fibers, and my own experiments, I have discovered papers made from many plants, ranging from common items such as wheat straw *(Triticum aestivum)* and hostas *(Hosta fortunei)* to things I would never think of using, such as seaweed. When you collect your first plant fibers, I recommend starting with a plant from one of the lists — one that is widely used to produce paper. After you become familiar with processing, feel free to go out on your own and experiment with new or unusual fibers.

Bast Fiber

The fibrous inner bark located between the outer surface bark and the inner core of trees or shrubs is called the bast. There are three types of bast fiber: woody, herbaceous, and petiole. Woody bast is found in the stems and branches of shrubs, such as blackberry; vines, such as kudzu *(Pueraria lobata)*; and trees, such as willow (*Salix* spp.). Herbaceous bast is found in the stems and branches of nonwoody annuals and perennials, such as nettles and milkweed (*Asclepias speciosa* or *A. syriaca*). Petiole bast is found in the leaf stalks and stems of long-leaved plants such as those in the banana family, like manila hemp *(Musa textilis).*

Once you have collected enough plant material, you will need to separate the bast fiber from the woody core and outer bark. In certain plants the bast fiber can be easily separated from the woody core after harvesting. With other plants you will need to steam or ferment the stalks in order to recover the bast fiber (see here).



Estimating Bast Fiber Yields

The number of paper sheets your fiber will make can vary greatly, depending on the fiber and the thickness of your paper sheets. As a very rough estimate, 1 pound (500 g) of bast and petiole fiber will produce about 30 thin sheets of 8 ½" x 11" paper, and herbaceous bast will produce just a bit less.

Collecting Woody Bast Fiber

If you cut a shoot of a tree, shrub, or vine and look at it in cross section, you will find the bast fiber between the outer black bark and the woody core. To collect this woody bast fiber, choose shoots or branches of tree that are ½ to 1 inch (1.25 to 2.5 cm) in diameter. Smaller shoots will have less fiber; larger ones might be tough to process. Cut the shoots at a 45-degree angle near the base or just above a bud, leaving the main plant intact so that it can continue to grow. (The angle is important, because it will help you later in the stripping process.) Many papermakers harvest bast fibers while they are pruning. Remember that you are using only the inner bark for papermaking, so you need a fair amount of branches to produce a small amount of paper.

In order to have enough bast fiber to make paper, you need to harvest at least five or six branches that are each approximately 5 to 6 feet (1.5 to 1.8 m) long, stripped of leaves

and twigs. This will yield approximately 1 pound (500 g) of bast fiber.

Collecting Herbaceous Bast Fiber

Herbaceous bast is collected much as you collect the bast of trees; by cutting the stalks at an angle. Annuals like hollyhock *(Alcea rosea)* and okra *(Abelmoschus esculentus)* can be simply pulled up by the roots. The roots, leaves, and twigs should be removed. (Hollyhock roots and okra fruit can be used for formation aid if they are cleaned and frozen — see here.)

Other People's Garbage Can Become a Papermaker's Fiber

Papermakers Jean and Bryan Battey moved to North Carolina a few years ago and set up a papermaking studio. Surrounded by fields of tobacco *(Nicotiana tabacum)*, an herbaceous bast fiber, Jean had an inkling that waste from the annual harvest might be made into paper. Each winter, farmers remove the dried leaves (which are used to make smoking tobacco) from their stalks and either burn the waste or send it to a landfill. One January, Jean asked a neighboring tobacco farmer if she could have the leftover stalks, and she received a truckload. Jean and Bryan processed the batch of tobacco stems into paper, and their studio, Laughing Fish, now produces naturally golden stationery and cards made from 100 percent North Carolina tobacco fiber (see paper sample below).

Collecting Petiole Bast Fiber

The petiole of a plant is the leaf stem that is connected to the stalk and supports the blade of the leaf. In manila hemp plants, the leaf stalks are often many feet in length and contain long strands of bast fiber, which are easily obtained once the stalks are cut from the plant. Many banana plants in the Musaceae family yield this type of fiber, and they usually have fibrous trunks as well. Petiole fiber tends to be very tough and can require extensive processing. To harvest, cut the leaf from the trunk of the plant and isolate the leaf stalk (in some cases, the leaf may be fibrous as well). Then pound or scrape the leaf away from the petiole fiber (see here).

➤ When harvesting bast fiber, do not collect branches of dead trees (the fiber will be impossible to strip).

Elizabeth Rappe

ABOVE: *A worker in Ecuador strips the petiole bast fiber from the long leaf stalks of the abaca plant, which can grow to lengths of 8 feet (3 m).*

Elizabeth Rappe

Leaf Fiber

In most cases, substantial elongated leaves, such as those of iris (*Iris* spp.), sisal *(Furcraea andina),* or yucca *(Yucca filamentosa* or *Y. elata),* are the best sources of leaf fiber for papermaking. To determine whether a leaf will yield paper, I check its tear strength — the harder it is to tear crosswise, the better the paper will be.

The easiest leaves to process come from plants like irises, gladioli (*Gladiolus* spp.), and lilies, whose flat leaves can be cut right from the plant and are ready to process directly into paper pulp. These types of leaf fiber can be collected in spring

or fall; they produce a green paper in spring and a brown paper in fall.

- **To harvest in spring,** cut individual outer leaves near the base of the plant. The leaves at the core should be left on the plant so that it can continue to grow.
- **To harvest in fall,** collect the leaves when they drop from the plant — a gentle tug will release the leaf from the tuber underground, where the leaf is connected to the plant.

Thicker, more fleshy leaves from swordlike plants like sisal hemp *(Agave sisalana)* and yucca have long stringy fibers inside that look like fishing line. These fibers are difficult and time consuming to process, and often require specialized equipment. Harvest these leaves as you would any others, removing only the outermost leaves and cutting them near the base. Their fleshy connective tissue should be removed immediately after harvesting by decortication, retting, or cooking (see here).

With any leaf fiber, you will need to have at least 1 pound (500 g) of dry fiber to make approximately 15 sheets of 8½" x 11" paper. The dry weight is tricky to determine if you are collecting fresh leaves — I usually collect more fiber than I think I will need.

➤ When searching for sources of leaf fiber, look for plants whose leaves structurally hold themselves upright.

ABOVE: *A sisal field in Ecuador. Notice the elongated leaves, which are an excellent source of leaf fiber.*

Finding New Uses for Sisal

I recently took a trip to Ecuador, where a small community is making paper with sisal leaves. Sisal farmers there have grown and harvested the plant for decades, and until recently they sold the fiber, which was used to make coffee sacks, rope, baskets, mats, handbags, hats, and other products — everything, it seems, except paper. Recently, however, the market for the sisal had practically vanished due to the introduction of synthetic materials. While talking to a papermaker, a community-development worker who

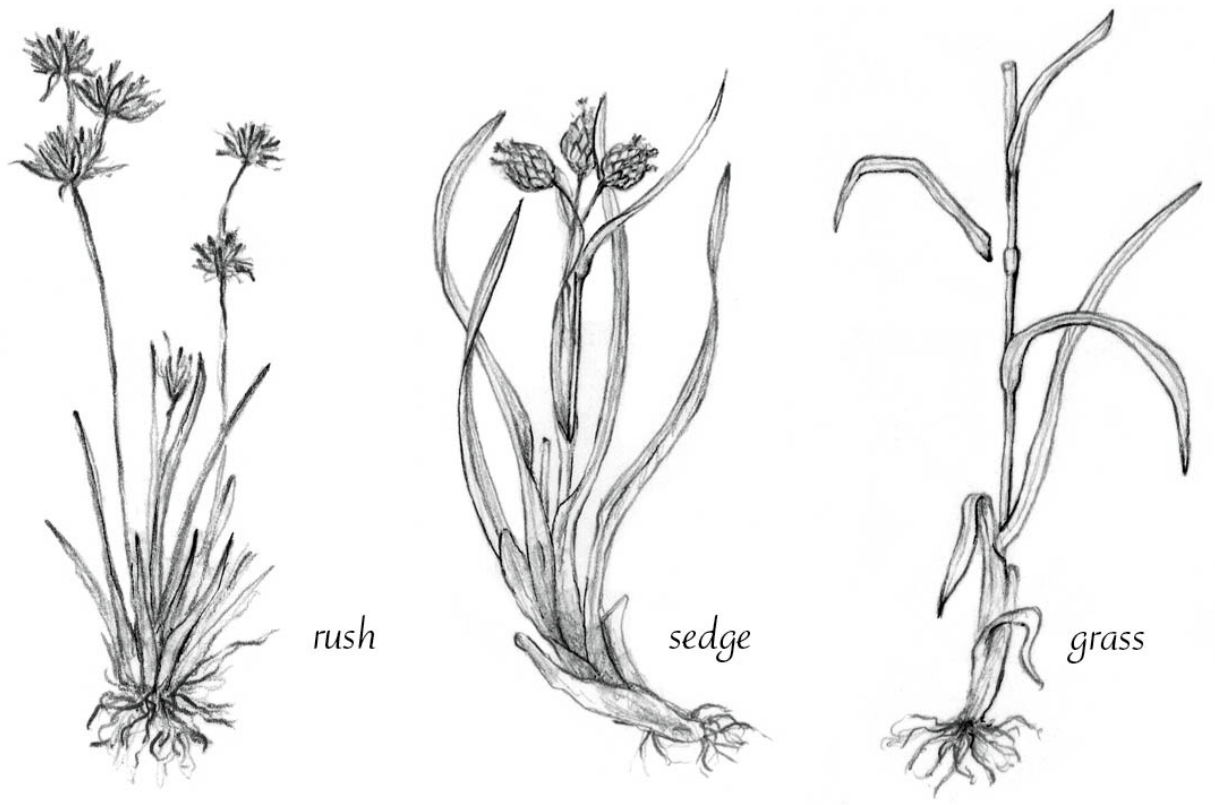
was searching for an innovative way for the farmers to use sisal discovered that sisal was indeed a papermaking fiber. So to generate income for the farmers and conserve an area of biodiversity by teaching them an environmentally friendly occupation, a full-scale papermaking production facility has been developed by CARE Ecuador (see paper sample below).

Grass Fiber

The short fibers of grasslike plants contain less cellulose and are more brittle than leaf or bast fiber, but nevertheless they make interesting papers. Tall weeds and wild grasses such as straws, rushes, sedges, swamp grasses, and beach grasses are good sources of papermaking fiber. You can even use

cornstalks and corn husks. Many grasses can be harvested in any season and are relatively simple to process.

The best papermaking grasses are the ones that are the most difficult to tear. When you find a good source, collect all but the roots and remove the nongrassy parts of the plant, like cattail spikes and wheat fronds.



ABOVE: *Three widely available sources of grass fiber are rush, sedge, and any of the various grasses.*

Some grasses, such as bamboo *(Phyllostachys aurea)* and sugarcane *(Saccharum officinarum),* are extremely tough and must be crushed or shredded. Some papermakers use garden shredders to crush tough grasses. However, if you live in an

area where sugar is processed, you may be able to obtain leftover crushed stalks, called bagasse, directly from a manufacturer. (Mix bagasse with another fiber, since it does not hold together well on its own.)

With grass fiber, 1 pound (500 g) of dry fiber will yield about 10 small, lightweight sheets of paper. Collect more fiber than you think you will need to ensure that you have enough. You can always dry and store the rest for future processing (see here).

➤ Don't base the amount of grass fiber you collect on volume; base it on weight. Grass fibers are filled with air and are deceptively lightweight.

Other Plant Fibers

There are many fine sources of papermaking fibers that do not fall into the above categories. For example, one papermaker in Oregon collects seaweed that washes up from the ocean after storms and makes a beautifully translucent brown-flecked paper. Another papermaker in England uses mango skins to produce lovely sheets. I have seen papers made from mushrooms and other fungi, and even from rhinocerous dung (which is practically a grass fiber). You can try making paper with just about any plant — if the plant doesn't yield a fibrous pulp, you can use it as a decorative element.

- **Seed fiber.** Cotton *(Gossypium hirsutum)* is one of the most widely used raw materials for hand papermaking in the

United States. After cotton has been ginned for textiles, weaker fiber left on cotton seeds is collected for papermaking. This fiber is processed into rough sheets, called cotton linters, which can be processed in a blender or a Hollander beater (see Fiber Preparation). Paper also can be made from cotton rags, such as your old ratty blue jeans and cotton T-shirts, but doing so requires a lot of work — the rags must be cut into tiny squares and beaten in a Hollander beater.

There are many other types of seed fiber you can harvest from the field, including thistle, kapok, and milkweed. Just gather the tufts or remove them from their seed pods.

- **Purchased fibers.** If you do not want to collect your own plant fibers, you have many options for purchasing raw or already-processed fibers. You can buy many fibers from mail-order suppliers (see Resource Guide), including preprocessed fibers (like cotton linters); some semiprocessed fibers, such as abaca, Spanish flax, and esparto grass *(Stipa tenacissima)*, in sheet form; the three traditional Japanese bast fibers, kozo, mitsumata, and gampi; and some grass, leaf, and seed fibers, such as wheat straw, raffia *(Raphia farinifera)*, and kapok *(Ceiba pentandra)*, in their raw, unprocessed form. Long, strong, flexible fibers like raffia and flax can be purchased at weaving supply shops. Sometimes you can even find sisal, jute *(Corchorus capsularis)*, and other strong natural fibers for sale at your local hardware store in the form of string or rope.

- **Decorative fibers.** Plants that you might expect to make the most beautiful papers may not contain enough fiber to hold together as sheets. Flower petals and tree leaves will not produce sheets by themselves, but when tossed into a vat of a more substantial pulp, they add a decorative touch to the sheet. Pigmented decorative plant material like flower petals should be blanched before it is added to a base pulp to prevent the color from bleeding. See Fresh Flower Petal Paper for instructions.
- **Recycled fibers.** If you don't have the energy to hunt for plants or the money to purchase fiber, you can often find all the raw materials you need in your garbage can or on your kitchen table. Instead of throwing or giving away your junk mail, newspapers, and magazines, for example, why not recycle them yourself? Just remember that each time a sheet of paper is recycled, it becomes slightly weaker. See the Paper from Preprocessed Fibers recipe for instructions on processing recycled fibers.

ABOVE: *From bottom, clockwise: abaca, cotton linters, sisal string, jute string, gampi, raffia.*

Fiber Storage

If you do not plan to use your fiber right away, dry it and store it. The chart below tells you what steps you will have to take before bundling and storing different fibers. Note that the bast and swordlike leaf fibers need further processing before they can be dried (see here).

It is very important to prevent mold and mildew when drying and storing, so that you do not damage your fiber. To dry fiber, hang it or lay it out on a screen so air can circulate all around it. Once the fiber has dried, tie it in bundles for storage and label it. If you must bag your fiber, put it in paper, mesh, or

cloth sacks. Do not store fiber in plastic bags, which trap moisture.

Fiber Storage Preparation

FIBER TYPE	PRESTORAGE PREPARATION
Woody bast	Steam and strip, clean, and dry
Herbaceous bast	Steam and strip, clean, and dry
Petiole bast	Harvest, scrape, and dry
Leaf (irislike)	Harvest and dry
Leaf (swordlike)	Harvest, remove fleshy material by decortication, scraping, or retting, and dry
Grass	Harvest and dry

Keeping a Detailed Record: Part I

Often, you have to go through the entire process of fiber preparation just to determine whether or not a plant is even suitable for papermaking. It is helpful to document your processing by keeping records so that you can replicate a sheet in the future. This will also help you when you're preparing plants in the same botanical family, because they might require similar processing. If you are not satisfied with a sheet of paper, good record keeping can help you refine your process and improve the quality of your work.

The sample below outlines the initial information you will find useful to record. This is the beginning of your papermaking record. As you progress, you'll add more information (see here) and, if you like the finished sheets of paper, the record will become your papermaking recipe.

Fiber Collection Record

Plant's common name: Daylily

Botanical name: Hemerocallis fulva

Plant family: Liliaceae

You should keep track of which plant made what paper. It will help you identify other potential papermaking plants in the same family. For example, bowstring hemp (Sansevieria trifasciata) and yucca are also both in the Liliaceae family and are known to make paper.

Date collected: Fall 1996

The season in which the plant was harvested can affect the color of the paper.

Your name: Helen Hiebert

Important if people other than you will use the data collected.

Part of plant used: Leaf

Did you harvest the inner bark, leaves, or another part of the plant?

How harvested: Collected leaves that had fallen off the main plant

Did you cut branches from trees? Did you wade into a marsh to collect swamp grass?

Where harvested: A friend's backyard in Red Hook, New York

This is useful information if you ever wish to harvest the same plant again.

Weight of dry fiber: ½ pound (230 g)

This will determine the amount of alkali you will use to cook the fiber. It can also be used to determine the yield of usable fiber in the plant.

CHAPTER 2

Getting Ready to Make Paper

The first step in preparing yourself for papermaking is to have a general understanding of the entire process. There are several pieces of equipment you will need to set up your workspace, and putting some thought into the flow of the process will make things run smoothly. Once you become familiar with the process, there are innumerable variations and specialized techniques that you can employ to make beautiful handmade paper.

An Overview

There are several steps involved in making a sheet of paper. First, you must obtain raw material (papermaking fiber) by harvesting plant material or purchasing fiber from a papermaking supplier. Once you have selected your fiber, you must process it, or break it down into the tiny individual strands that will bond with each other to form your sheets of paper. This processing varies from fiber to fiber. Most plant fibers require cooking, and all fibers must be beaten — using methods such as hand beating, processing in a blender, or beating in a hollander beater — to break down and hydrate the fiber, turning it into paper pulp. After beating, the pulp is mixed with water in a vat. You must then dip your mould and deckle (a frame that molds and supports the fibers in sheetlike form), in and out of the vat of pulp, allowing the pulp to settle on the screened surface of the mould as the water drains through the holes in the screen. The pulp settling onto this screened surface becomes the sheet of paper. Remove the deckle, tilt the mould (and your sheet of paper) to let the excess water drain off, and then transfer, or couch, the sheet of paper onto a felt or blanket. You can couch multiple sheets of paper one on top of the other, each separated by a layer of felt or blanket. You must press the sheets to remove most of the remaining water, and then dry them using one of the techniques described in chapter 4.

Tools and Equipment

The equipment list at right includes the fundamental tools you will need to form sheets of paper. Depending on how simple or elaborate you wish to be, there are many quality grades and price ranges to choose from. If you are a do-it-yourselfer, most of the equipment can be constructed simply. Other supplies can be obtained from sewing stores, secondhand stores, and hardware stores. If you are a one-stop shopper, there are several mail-order supply companies (see Resource Guide) run by professional papermakers who have spent years developing the best products. Equipment for preparing pulp is discussed in chapter 3, and you will find information on pressing and drying equipment in chapter 4.

BASIC PAPERMAKING EQUIPMENT

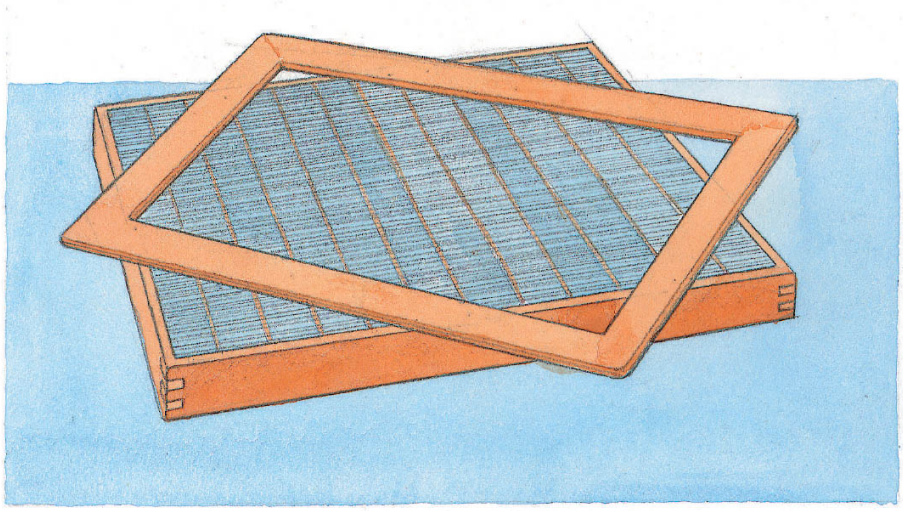
- Moulds and deckles
- Vat
- Felts
- Table, tray, or stand for couching
- Strainers lined with mesh or drain basket
- Scoops
- Plastic buckets with handles
- Sponges

Moulds and Deckles

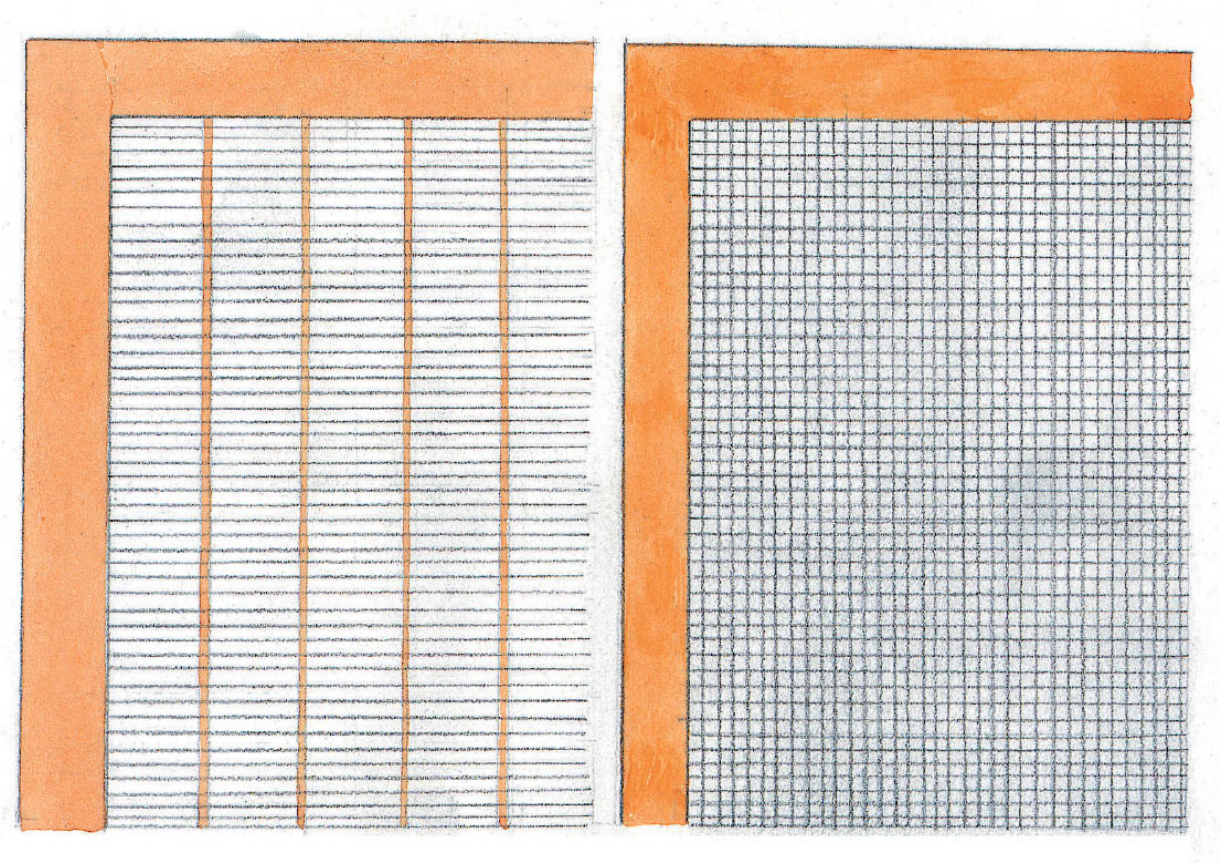
The mould is a screen upon which the sheet of paper is formed, and the deckle is a frame that holds the pulp on top of the mould and determines the size, shape, and thickness of the sheet of paper. The deckle (deriving its name from either the German word *deckel* or the old Dutch word *dekfel,* meaning "cover") creates *deckle-edged paper,* which refers to the soft feathered edges that sheets of handmade paper are famous for. There are many types of moulds and deckles, but the three most familiar are the Western mould and deckle, the Japanese *sugeta,* and the deckle box.

Western Moulds and Deckles

There are two types of traditional Western moulds, which vary in their screen surface: laid and wove. On a traditional laid mould, a series of parallel wires (laid lines) create the mould surface. These wires are sewn onto wooden ribs, spaced at approximately 1-inch (2.5 cm) intervals, that support the wires from below and prevent them from sagging under the weight of the pulp and water. The visible lines they create in the sheets of dry paper where they are sewn to the ribs are called the chain lines. The wove mould has a screen that has a woven-mesh surface resembling a fine window screen stretched across the frame. The surface of a sheet made on a wove mould is less distinctive and smoother than the laid surface.



ABOVE: *Professional Western-style moulds and deckles are made with hardwood, typically mahogany, that is water- and warp-resistant.*



ABOVE: *LEFT: Closeup of a laid mould surface; RIGHT: Closeup of a wove mould surface*

A Contemporary Mould Maker

Tim Moore has been making moulds professionally for about 15 years. He began when his wife's papermaking instructor asked him to make a pair of moulds to be used by students learning the craft. The instructor gave him an old British mould and had him cut it in half so that he could figure out how to construct the new moulds. He replicated the mould and deckle, and a few months later, someone else asked him

to make one. Soon he had a full-fledged business making papermaking and bookbinding equipment. Tim is a true craftsman, taking care in each step of the process: selecting the appropriate water- and warp-resistant wood; cutting and treating it in a certain way; reinforcing the most used parts of the mould to ensure longevity; spending time with papermakers and bookbinders to get practical advice on their needs. When he had a hard time locating the appropriate wire facings, Tim decided to make a loom for twining his own wire. Tim's moulds are exquisite works of art. To him, "toolmaking is a humble, social form of sculpture in which I play a limited part; tools, after all, have independent work lives."

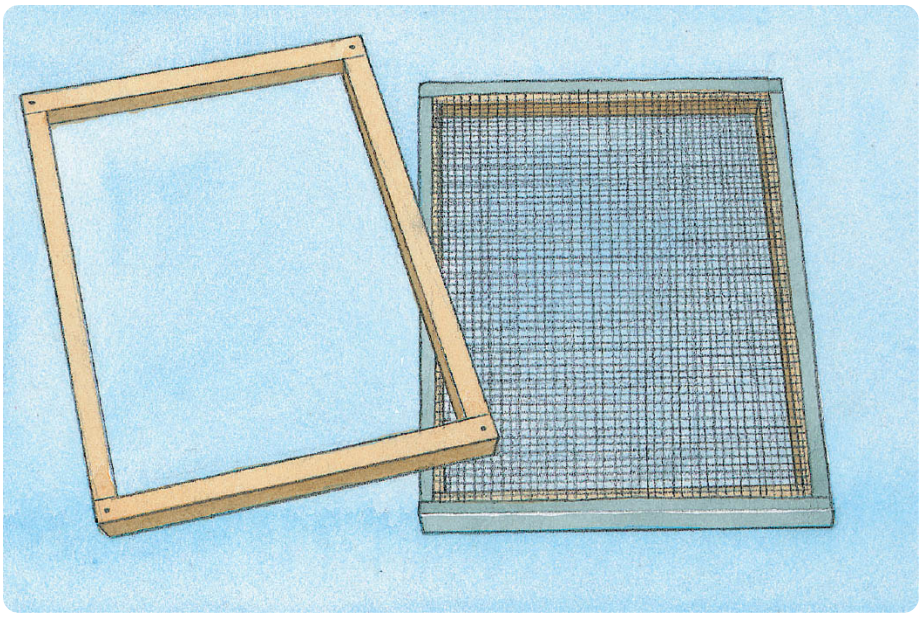
Tim Moore

ABOVE: *Two small laid moulds, 8 1/2" x 11" and 12" x 18"*

Make Your Own Western Mould and Deckle

It is quite easy to make your own mould and deckle, and you can use hard- or softwood. I made the following mould and deckle with needlepoint stretchers that were already jointed. If you have basic carpentry skills, you can purchase lengths of 1-inch-by-1-inch pine (or more expensive hardwoods) and joint them yourself.

This mould and deckle will form a sheet of 8 ½" x 11" paper.



ABOVE: *One of the simplest moulds and deckles to make at home is the Western-style made from prejointed canvas stretcher bars.*

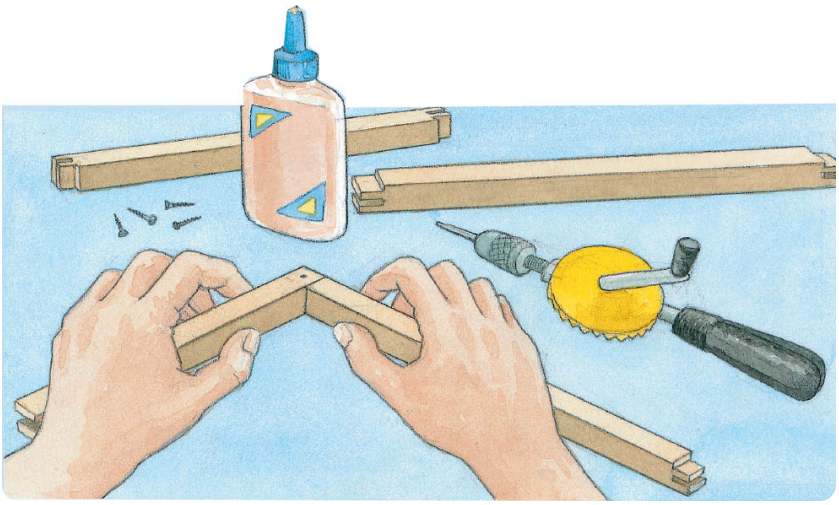
MATERIALS AND EQUIPMENT

- **4** prejointed needlepoint stretcher bars measuring 10" x ¾" x ¾" (available at sewing and craft stores)
- **4** prejointed needlepoint stretcher bars measuring 12½" x ¾" x ¾" (available at sewing and craft stores)
- Water- and weather-resistant wood glue
- Drill and drill bit
- Eight ½" brass or stainless-steel screws
- Sandpaper
- Small paintbrush
- Water-based polyurethane (oil-based is also okay, but I don't like the fumes)
- Tin snips for cutting wire
- Rustproof wire screen (window screen or finer), cut to 9½" x 12" (24 x 30 cm)
- Hardware cloth (a heavy wire mesh with ¼" mesh squares) cut to 9½" x 12" (24 x 30 cm)
- Rustproof staples and staple gun
- Duct tape
- Scissors
- ¼" or ½" foam insulating strips

➤ Marine supply stores are a good source of waterproof and rustproof items, such as paints, staples, screws, and clothing.

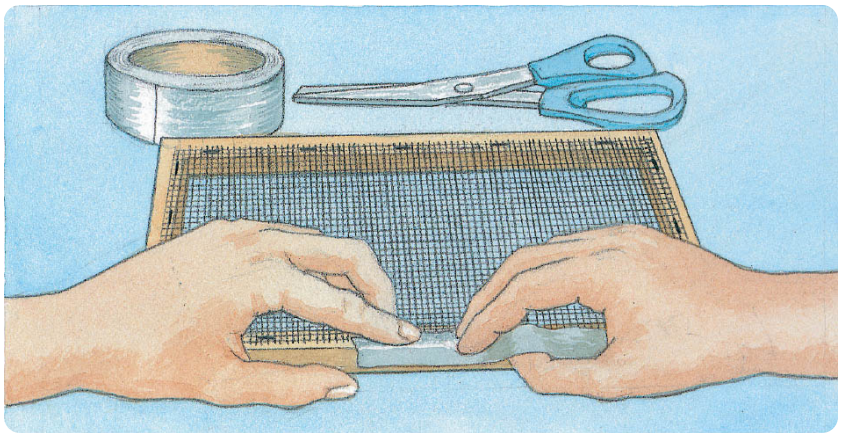
INSTRUCTIONS

1. Apply carpenter's glue to the joints and fit them together to form two wooden frames. Make sure the corners are square. Drill holes in the corners and fit with screws to secure the joints. Sand the surfaces to make them smooth and even.



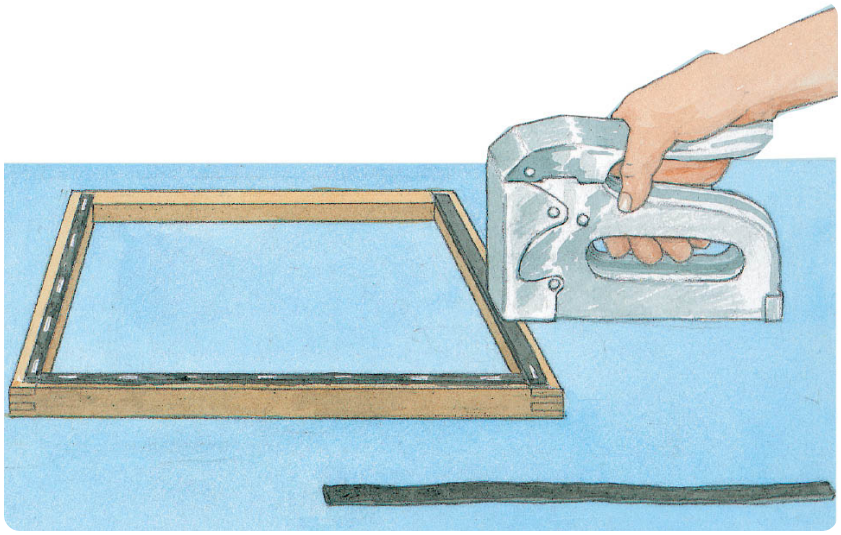
2. Apply polyurethane with a brush to waterproof the frames and let them dry at least overnight. I recommend applying a second coat.

3. To make the mould, place the window screen on top of the hardware cloth and lay the combined screen onto one of the frames. Center it and staple it to the frame at 1-inch (2.5 cm) intervals, keeping it taut. Put duct tape over the stapled edges to seal the screens and prevent pulp fibers from slipping between them. This also protects your hands from the sharp edges of the screens.

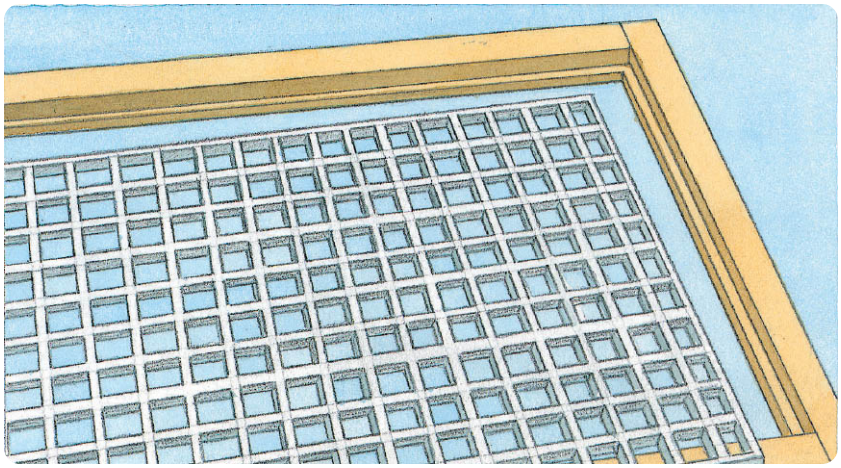


➤ There are alternatives to wire screening. Lee Scott McDonald, Inc., and Carriage House Paper (see Resource Guide) carry a heat-shrinking polypropylene screening that can be glued to the frame and tightened with the heat of a blow dryer.

4. To make the deckle, cut the foam strips to fit along the inside edge of the “window” on the other frame. Use a staple gun to attach the foam strips at 1-inch (2.5 cm) intervals.



➤ Your mould and deckle will wear over time, and the wire mesh may sag. This is why professional equipment has an extensive ribbing system. You can support your mould and deckle by cutting a rabbet groove on the pine lengths of the mould and sliding a piece of plastic grid (the kind used in fluorescent lighting) into it before you attach the screens. When using this type of mould, make sure you clean it well by spraying from the front with water, because pulp tends to get caught between the screen and grid.

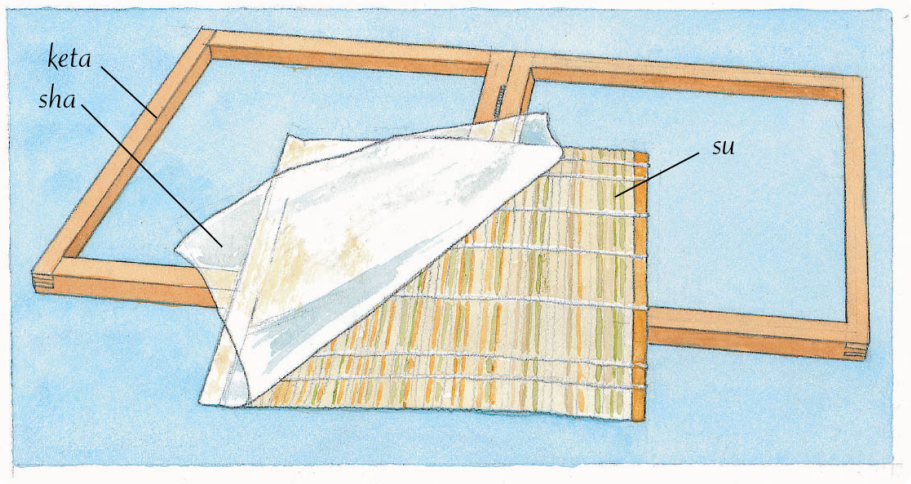


ABOVE: *A rabbet groove with plastic grid will help support a well-used mould and deckle.*

Japanese Sugeta

Many plant fiber papermakers use a *sugeta,* the Japanese equivalent of the mould and deckle, to make paper. Its name describes its parts: The *su* is the screen, which differs from the Western mould in that it is flexible, and the *keta* is a hinged

frame that supports the *su.* The *sugeta* is deeper than the Western deckle to accommodate the differing sheet-formation process (see Japanese Papermaking). You may find the Japanese-style papermaking process more suitable for some plant fibers, such as the long-fibered bast fibers, than the Western process, although you can experiment with the different processes to find out which one works best for your purposes.



ABOVE: *The flexibility of the screen on the Japanese sugeta can make couching easier with some plant fibers, especially when you're forming thin sheets.*

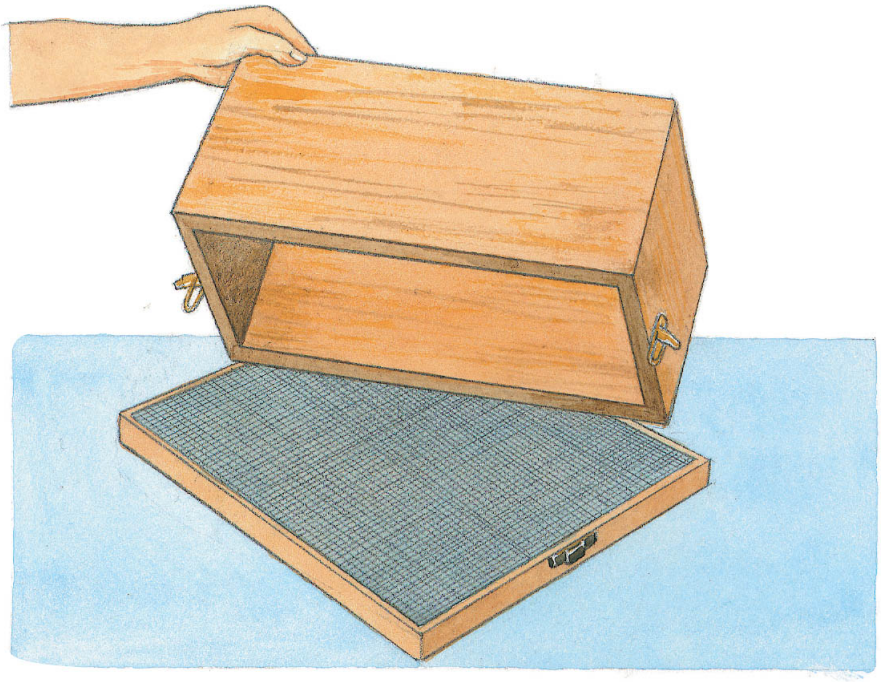
The traditional Japanese *su* is made from bamboo splints woven together with silk or nylon threads, and its design is based on earlier moulds made in China and Korea. Some *sus* are lined on one side with a *sha,* or a fine silk mesh. A simple adaptation is to use a rectangular bamboo place mat or a brush-wrapping mat with a piece of noseum netting sewn on

top of it. Refer to *Japanese Papermaking,* by Timothy Barrett, for a full description on making a place-mat *sugeta* and a traditional *sugeta.*

If you do not wish to construct a *sugeta,* you can adapt your Western mould for Japanese-style papermaking quite easily. Cut a piece of pellon (a polyester fabric) or plastic window screening to the outside dimensions of your mould. You can wrap a piece of duct tape around one of the long edges for easy handling (make sure the tape sits underneath the deckle and does not block the papermaking surface of the screen). When you are ready to make paper in the Japanese style, simply sandwich this *su* between your Western mould and deckle.

Deckle Box

Another type of mould and deckle is the deckle box, which is designed for pouring sheets of paper, rather than pulling sheets from a vat of pulp. The very first papers may have been made in this fashion on a square of woven cloth held within a bamboo frame. (Papers are still made using this method in some countries, including Burma, Nepal, and Tibet.) A deckle box has a deep deckle, which allows you to pour water and pulp into it (simulating a vat) to form a sheet. This type of mould is useful if you have a small amount of plant material (not enough to fill a vat) or if you wish to make a test sheet. It prevents you from having to fill up an entire vat just to pull one sheet of paper.

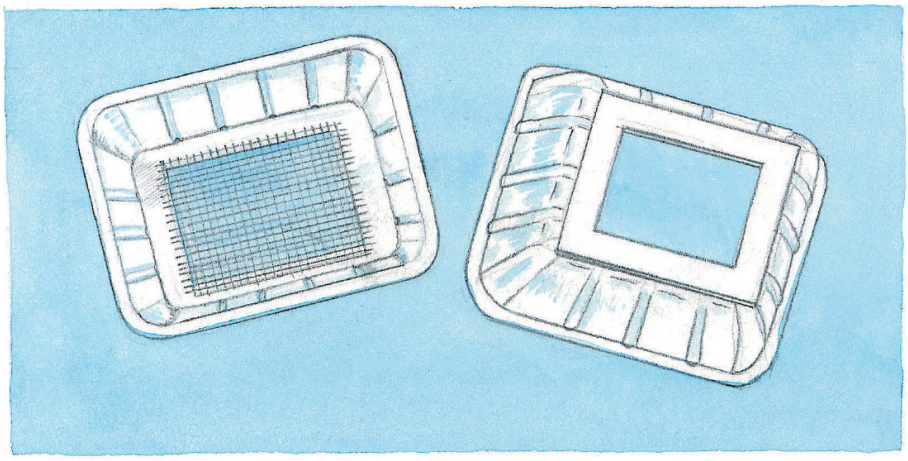


ABOVE: *The deckle box is designed for pouring sheets of paper, which is especially useful if you have only a small amount of pulp to work with.*

Test Moulds

A papermaking colleague once showed me how to make a mould and deckle out of two solid plastic berry or deli containers. She uses it as a test mould for making small samples to test her paper for uniformity, thickness, or color. Just cut a section of the bottom out of both containers, leaving at least ½ inch (1.25 cm) of the bottom intact around the edges. Glue foam strips around the bottom edge of one of the containers. Cut a piece of stiff mesh (like wire window screen) that is larger than the hole, but small enough to fit into a container and fit it into the bottom of the other plastic

container. Slide the foam-bottomed container into the mesh-bottomed container to assemble your mould and deckle. Kids love this little mould. On a larger scale, a deckle box can be constructed similarly using two identical plastic tubs.



ABOVE: *Be sure not to attach the mesh screen to the plastic container — it must remain loose so that you can remove it for couching after pulling a sheet (see here).*

The Vat

The vat is the container in which you form sheets of paper. It can be as simple as a plastic dishpan, or it can be custom designed and built from wood or stainless steel. I do not advise using your kitchen sink or your bathtub, because pulp will inevitably clog your drains.

Your vat must be larger than your mould and deckle, with at least 5 inches (12.5 cm) of space on every side for easy dipping. The depth should be at least 6 inches (15 cm) for small sheets,

so that you can scoop down far enough to gather the pulp. It does not need to be deeper than is comfortable for sheet formation. Deeper vats require more water and pulp, and they also take longer to fill and empty.

- **Tabletop vats.** Dishpans or plastic utility tubs make excellent tabletop vats.
- **Standing vats.** Freestanding plastic and fiberglass utility sinks without plumbing make perfect standing vats, and they have drain plugs, which makes them easy to empty. It is nice to have standing vats on caster rollers, for easy mobility and cleaning.
- **Homemade wooden vats.** If you want to make your own wooden vat, you will probably want to include drainage holes that are drilled and plugged, and corners that are reinforced with sealant. The entire vat should be painted and waterproofed.

Scoopers and Strainers

These two items are essential in the studio. Cut the bottom off an old plastic ½-gallon milk jug (with its top still on) to create a handy scoop with a handle for scooping pulp into or out of your vat. Strainers have many uses in the paper studio, such as collecting excess pulp when emptying your vat. Kitchen strainers work fine, but you should line them with a finely woven mesh to collect tiny pulp fibers and prevent them from clogging your drain. Cone-shaped strainers such as those used in the restaurant industry fit nicely into 5-gallon (19 l) plastic

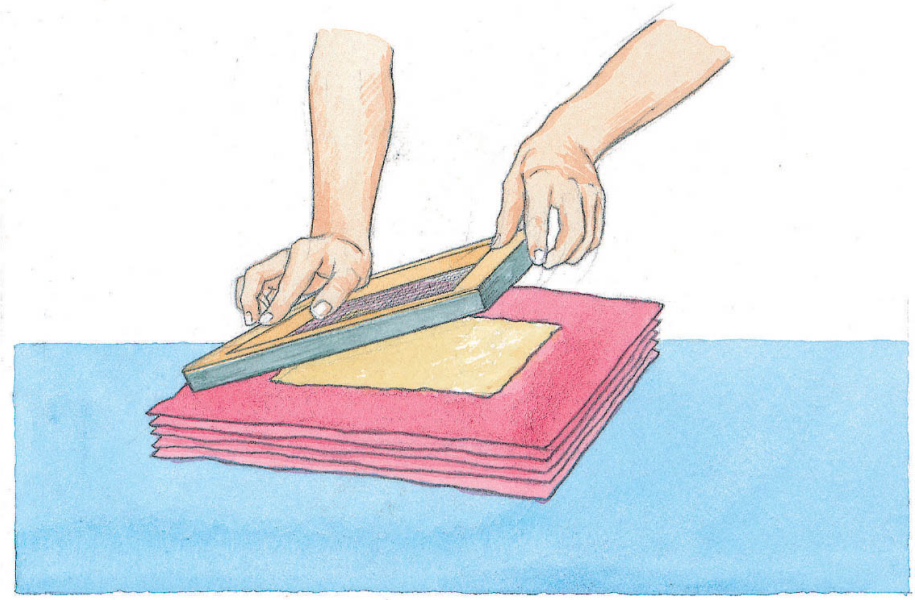
buckets. For small studios without a floor drain, plastic-bowl-type strainers that fit on top of a 5-gallon (19 l) bucket are available from ceramic supply stores. As you strain your pulp, the water is collected in the bucket, and can then be poured into a sink.

➤ A lot of water is used during the papermaking process. You might want to set up a water recycling system by straining into a larger bucket that collects the water.

Felts

After sheets of paper are formed, they are transferred from the mould to felts, pieces of woven wool fabric with a smooth brushed surface. This process of transferring a freshly made sheet of paper from the mould surface onto a felt is called couching (pronounced *cooch*-ing). The absorbent qualities of the felt help you release the sheet of paper from the mould so that you can use the mould to make more sheets. Traditionally, wool felts are used. Old woolen army blankets make great felts, and you can often find them at secondhand shops. If you live near a commercial papermill, you might ask if it has any old papermaking machine blankets that you could cut up and use. Nonfusible pellon, or interfacing, available at fabric stores, is also an excellent lightweight material that works well as a felt substitute. It comes in different weights — I like the heavyweight pellon. Papermaking suppliers also carry an assortment of couching materials (see Resource Guide).

Your felts should be cut to approximately 2 inches (5 cm) larger on all sides than the sheets of paper that will be couched onto them, and small enough to fit into your press. For larger operations, felts can be cut bigger to accommodate more than one sheet each. Felts and paper can be stacked, alternating felt and paper, forming a *post* of paper so that you can press many sheets of paper at the same time.



ABOVE: *Couch sheets of paper in a stack, alternating felt and paper, to form a post.*

The Truth about Felts

The term felt is actually a misnomer. Papermaking felts are woven, although they have the texture and surface of real felts, which are matted. If you use true matted felts,

you will most likely have a problem with them losing their shape and not holding up over time. The term felt is often used by papermakers to refer to any couching material.

Couching Surface

Form your sheets of paper on top of a waterproof board or tray, so that your pile of felts and paper (the post) can be transported easily. (You can adequately waterproof a wooden board for couching with two coats of polyurethane.) Note that when making paper, water will drip off the couching surface onto your table or floor. If this is a concern, you should use a tray, like an industrial baking sheet or a cafeteria tray, that will collect excess water.

Setting Up Your Work Area

There are several steps in the papermaking process, and you might choose to do them all in one location, or you may prefer to prepare your fiber in one location and make paper in another. Take the time to plan a layout for your papermaking studio. There is a certain order to the process (as you will see in the following chapters), and it is well worth your while to set up accordingly.

- Make sure your work area is free of electrical hazards. If possible, install your outlets up off the ground to prevent

them from being exposed to water. Keep extension cords well above the floor and far away from faucets and hoses.

- Keep a kitchen scale handy for weighing ingredients.
- Cook in a well-ventilated area.
- Beating can be done anywhere — just be aware that the pounding or blending can be noisy.
- Work near your water supply to avoid lugging heavy buckets of water back and forth. A garden hose with a spray nozzle is a papermaker's best friend.
- Keep a supply of plastic buckets of all sizes in your workspace. They come in handy in the transportation of water and pulp, and extra pulp can be stored in a bucket under the table for easy access when you need to replenish the vat.
- Use a level shelf, cabinet, or table for storing moulds and deckles. They should be laid flat when not in use to prevent warping.

You do not need a very large work area for the actual papermaking. You just need access to water, a table, and a floor that can get wet. One easy solution is to work outdoors. Keeping your work area clean can be tricky outside, however, especially if it is windy, buggy, or sandy. "Stuff" tends to end up in your pulp or your paper. You can reduce this by covering your buckets and vats with mesh or plastic when they are not in use. If you want to work inside but are worried about damaging your floor and table, cover your table and the surrounding floor with newspaper and/or plastic. Duct tape is

strong and waterproof and can be used for securing plastic. Wherever I work, I line my strainer or drain with a fine-mesh or muslin cloth to collect tiny fibers and prevent clogging.

Set your vat on a table surface at a comfortable height. Place your couching station right next to it so that you do not have to carry your wet mould and sheet of paper very far. Keep additional felts nearby, where you can grab them as you need them. Have your pressing and drying equipment at hand and ready to go so you can easily transfer your sheets from one workstation to the next.

➤ If you wish to remain dry when making paper, wear a rubber apron and waterproof shoes or boots.

Caring for Your Equipment

It is very important to properly care for your papermaking equipment to assure that it will last for a long time. Paper pulp sticks to everything and is easiest to remove when still wet. Immediately after you've finished papermaking:

- Thoroughly clean your mould and deckle and let them dry out after use. Avoid spraying water through the backside of the mould, because it could force fiber deeper between the layers of mesh.
- Thoroughly rinse your pellons or felts to remove bits of pulp that might stick to the next sheet couched onto them.

- Rinse out buckets, vats, and any other containers you use so that the pulp residue does not dry stuck to your equipment. Wait until your buckets are dry before you stack them together — they stick to each other if stacked when wet and are practically impossible to separate.

CHAPTER 3

Processing Plant Fiber

Fiber preparation is possibly the most important step in the papermaking process. The instructions that follow are general guidelines. As you read, you will discover that there are many variables to each step of the process. Through my own experiments, research, and discussions with other papermakers, I have come to realize that there is no single best way to complete any part of the process. Fortunately, there seem to be many right ways to process pulp, but not so many wrong ways. It is difficult to completely ruin paper pulp, but it does take skill and experience to utilize the full potential of a fiber. Varying the process will just produce different results in the paper — thick or thin, smooth or rough, strong or weak, translucent or opaque, and so on. A big part of the joy of papermaking is discovering new methods and techniques. The more experimenting you do, the more familiar you will become with how a subtle change in processing techniques will affect your sheets of paper.

Archival Papers

Papers that are pH neutral (neither acidic nor alkaline) are considered archival because they will not deteriorate over time. If you are concerned about the longevity of your papers, this is the ideal that you should strive for.

Cellulose, a material present in the cell walls of all plants, is the building block of paper. When acidic or alkaline noncellulose materials are present in paper, they will eventually cause the cellulose to break down, resulting in discolored and brittle paper.

Papers made from wood (including most commercial papers) are often treated with acidic or alkaline chemicals, which remain in the paper and break down the cellulose in the paper over time. In addition, some noncellulose materials are not removed from the wood, making the paper unstable and susceptible to decay. A typical example is a piece of newspaper. Leave it outside for a few weeks and it will become crumbly and yellow. Decay isn't a concern for paper that is used for a day and discarded. It is a primary concern for artists and conservators, however, who want their work to be preserved for hundreds of years.

Acidity and alkalinity can be measured using a pH test strip, which is similar to litmus paper but measures the pH on a scale from 1 (extremely acidic) to 14 (extremely alkaline). If you are concerned about the pH of your paper, you can test it at the following stages of processing:

- **Water purity.** First, check your water supply. The pH of your water should be close to 7 (neutral). Ideally, it should also be free of pollution, microbes, particulate matter, chlorine, iron, and copper. Contaminants such as these can damage your paper; for example, iron causes foxing (small discolored spots) in paper, which will show up when the paper is dry. Consult with your city water department, or a company that sells water filters, to determine how to treat your water if it is less than ideal.
- **The cooking solution.** When cooking, the pH of the cooking solution should be between 10 and 11 — below 10 is too weak, and might not break down the fiber, and above 11 could damage the cellulose.
- **The rinse water.** During washing, you can test your rinse water until the pH drops to close to or equal to the pH of your water

supply.

- **The sheet of paper.** After making a sheet of paper and couching it, lay an indicator strip on top of the sheet so that it absorbs some water and then compare it to the pH chart. A pH of between 7 and 8 is considered neutral for paper. A pH reading of 7 is truly neutral, but a slightly alkaline paper will be buffered against the acidic contaminants in the atmosphere. If the pH is over 8.5, the paper will deteriorate at a faster rate.

Pulp Purity

Noncellulose materials, such as lignins, pectins, waxes, and starches, hold the plant together as it grows, but they inhibit the papermaking process. Lignin in particular is water resistant and keeps the fibers from separating freely during the beating cycle, which is necessary for even sheet formation. Noncellulose materials can also cause discoloration and deterioration in sheets of paper. In order to prepare the purest papermaking pulp, these noncellulose materials must be removed by cooking or retting.

Fiber Preparation

There is a series of steps you must follow after collecting your plant fiber before you can make it into sheets of paper. All plants must be cooked and beaten to obtain the fibrous material that constitutes paper pulp (the wet, ground-up plant fiber from

which paper is made), but some require further processing, such as retting, steaming, or stripping. Fiber preparation is just one step in transforming plants into paper, but by varying the way you cook or beat the fiber, you can change the characteristics of the resulting sheets of paper.

Cooking the Fiber

All plant fibers must be cooked in an alkali solution, called a caustic solution, prior to making paper. Cooking breaks down the fiber into a pulpable material. With the aid of an alkali, such as soda ash, washing soda, lye, or lime, the noncellulose materials like lignins, pectins, waxes, and gums are dissolved and then rinsed out.

When I first started making paper, I was experimenting with onion skins. I didn't know about alkalis, so I just boiled the skins in plain water. Ten hours later, they were mushy enough to make into paper. Soon after that, somebody told me about alkalis and I shaved many hours off my cooking time (most plant materials will in fact break down in 2 to 3 hours in an alkaline solution). I also learned that by not using an alkali, I probably wasn't getting rid of all of the noncellulose materials, which would over time weaken, discolor, and/or accelerate the deterioration of the sheets of paper.

If you are working with a soft leaf (daylily or gladiolus, for example) or soft grass fiber (straws or weeds, for example), the noncellulose materials can be removed simply by cooking the fiber in a caustic solution. However, if you plan to use bast fibers or tough leaf fibers containing long stringy strands, there are

several additional fiber preparation steps that you must complete to prepare the material for cooking (see here).

Types of Alkali

You should cook your fiber in the least amount of the gentlest alkali that will break it down. Trying to speed up the process by using a stronger alkali or increasing the amount could damage the fiber. You can adjust the ratio as you gain experience, adding less alkali for weaker fibers and more for tough fibers. Keeping a record of how you prepare certain fibers will give you some guidelines.

There are several alkalis that you can use, but the one most commonly used by papermakers is soda ash, which is inexpensive and available from papermaking suppliers. Generally, if you need to cook for longer than 3 hours in a standard 20 percent solution of soda ash, you should rinse the fiber and try cooking it with lye, which is stronger. If lye doesn't break it down, you should probably resort to retting (see here).

Many papermakers determine the amount of alkali they use based on a percentage of the weight of the dry fiber. For example, the standard amount of soda ash used for cooking is 20 percent of the dry fiber weight; if you want to cook 1 pound (16 ounces, or 500 g) of fiber, the formula to determine the amount of soda ash to use is 16 x .20, which yields 3.2 ounces (90 g), which I round up to 3.5 ounces (100 g). The alkali is then mixed with enough water to cover the fiber and allow it to move about freely in the pot. Eight quarts (8 l) of water is generally enough to cover 1 pound of fiber.

Cooking Safely

- Never use aluminum pots, which react with the alkali and give off a gas. Use stainless-steel, enamel-coated, or glass pots.
- Use stainless-steel, heat-resistant plastic, glass, or wood stirring utensils and tongs.
- Keep your cooking utensils and pots separate from your papermaking utensils and pots, and, if possible, do not work in your kitchen.
- Use a hooded or vented stove to protect yourself from cooking vapors, or cook outside.
- Add alkali to water before it boils; do not add boiling water to alkali or vice versa — it could splatter and burn you.
- Add fiber after alkali is well mixed with water to ensure even dispersal of alkali with fiber in the cooking bath.
- Wear rubber gloves and goggles or a face mask when working with all caustics to protect your face from splatters.

Common Alkalis for Papermaking

NAME	WHERE AVAILABLE	SUGGESTED USAGE*	USAGE FOR 1 LB. (500 G) OF DRY FIBER	COMMENTS

NAME	WHERE AVAILABLE	SUGGESTED USAGE*	USAGE FOR 1 LB. (500 G) OF DRY FIBER	COMMENTS
Soda ash (Na_2CO_3)	Papermaking and ceramic suppliers	20%	3.5 oz. (100 g) soda ash and 8 quarts (8 l) of water	The most common alkali used in papermaking. Works for most plants.

*as a percentage of dry fiber weight

**Lye in the United States is diluted but in some countries it is pure. If using lye from another country, ask wether it is pure and if so, use less.

NAME	WHERE AVAILABLE	SUGGESTED USAGE*	USAGE FOR 1 LB. (500 G) OF DRY FIBER	COMMENTS
Washing soda (the detergent)	Supermarkets	20%	3.5 oz. (100 g) soda ash and 8 quarts (8 l) of water	A little less pure than soda ash (it contains other chemicals that may leave a residue on the paper and cause it to decay more quickly), but easy to obtain.
Wood ash lye (KOH)	Make your own from woodstove or fire ashes	—	26 oz. (730 g) of wood ash and 15 quarts (14 l) of water	Less predictable and more time

*as a percentage of dry fiber weight

**Lye in the United States is diluted but in some countries it is pure. If using lye from another country, ask wether it is pure and if so, use less.

NAME	WHERE AVAILABLE	SUGGESTED USAGE*	USAGE FOR 1 LB. (500 G) OF DRY FIBER	COMMENTS
				consuming than soda ash, but may yield a more permanent paper due to gentle cooking action and tendency to rinse out more easily. Because it is itself the liquid in which fiber is cooked, it isn't measured as a percentage of dry fiber

*as a percentage of dry fiber weight

**Lye in the United States is diluted but in some countries it is pure. If using lye from another country, ask wether it is pure and if so, use less.

NAME	WHERE AVAILABLE	SUGGESTED USAGE*	USAGE FOR 1 LB. (500 G) OF DRY FIBER	COMMENTS
				weight. To make wood ash lye solution, boil ash in water for half an hour and let settle overnight. Then siphon or pour off clear solution. Make enough to cover fiber so that it can move about freely. (Amounts formulated for 1 pound

*as a percentage of dry fiber weight

**Lye in the United States is diluted but in some countries it is pure. If using lye from another country, ask wether it is pure and if so, use less.

NAME	WHERE AVAILABLE	SUGGESTED USAGE*	USAGE FOR 1 LB. (500 G) OF DRY FIBER	COMMENTS
				[500 g] of dry fiber will yield between 7.5 and 10 quarts [7.5 and 10 l] of lye solution.)
Lime (Ca(OH)2, calcium hydroxide)	Papermaking suppliers, building supply stores	6%	1 oz. (30 g) of lime in 8 quarts (8 l) of water	Since lime is less active than soda ash, the cook time may be longer (up to 5 hours).
Caustic soda (NaOH), also known as sodium hydroxide or lye**	Grocery stores	15%	2.4 oz. (70 g) in 8 quarts (8 l) of water	Use as last resort with tough fibers —such as herbaceous

*as a percentage of dry fiber weight

**Lye in the United States is diluted but in some countries it is pure. If using lye from another country, ask wether it is pure and if so, use less.

NAME	WHERE AVAILABLE	SUGGESTED USAGE*	USAGE FOR 1 LB. (500 G) OF DRY FIBER	COMMENTS
				basts and tough leaf fibers—that will not break down within two to three hours with soda ash. Use caution: Lye can be dangerous. First add lye to small amount of cold water. Then pour solution into unheated cooking water before adding fiber

*as a percentage of dry fiber weight

**Lye in the United States is diluted but in some countries it is pure. If using lye from another country, ask wether it is pure and if so, use less.

NAME	WHERE AVAILABLE	SUGGESTED USAGE*	USAGE FOR 1 LB. (500 G) OF DRY FIBER	COMMENTS
				(lye can splatter explosively if added directly to hot water).

*as a percentage of dry fiber weight

**Lye in the United States is diluted but in some countries it is pure. If using lye from another country, ask wether it is pure and if so, use less.

Step-by-Step Cooking

The instructions that follow are for using soda ash, the most common alkali, which works with most plant fibers. This recipe is based on using 1 pound (500 g) of dry fiber — the husks from 30 to 40 ears of corn weigh 1 pound — which is a good amount to start with, because it will yield enough pulp to make several sheets of paper.

➤ If you're worried about ventilation, you may want to cook on a hot plate or camping stove outdoors or in a garage to avoid inhaling the fumes.

MATERIALS AND EQUIPMENT

Large cooking pot (a nonreactive, nonfood pot; stainless steel is ideal)

Soda ash

Scale (a kitchen or postal model that has measurements in ounces or grams)

Pot holders

Stirring utensils (nonfood utensils made of stainless steel, wood, heat-resistant plastic, or glass)

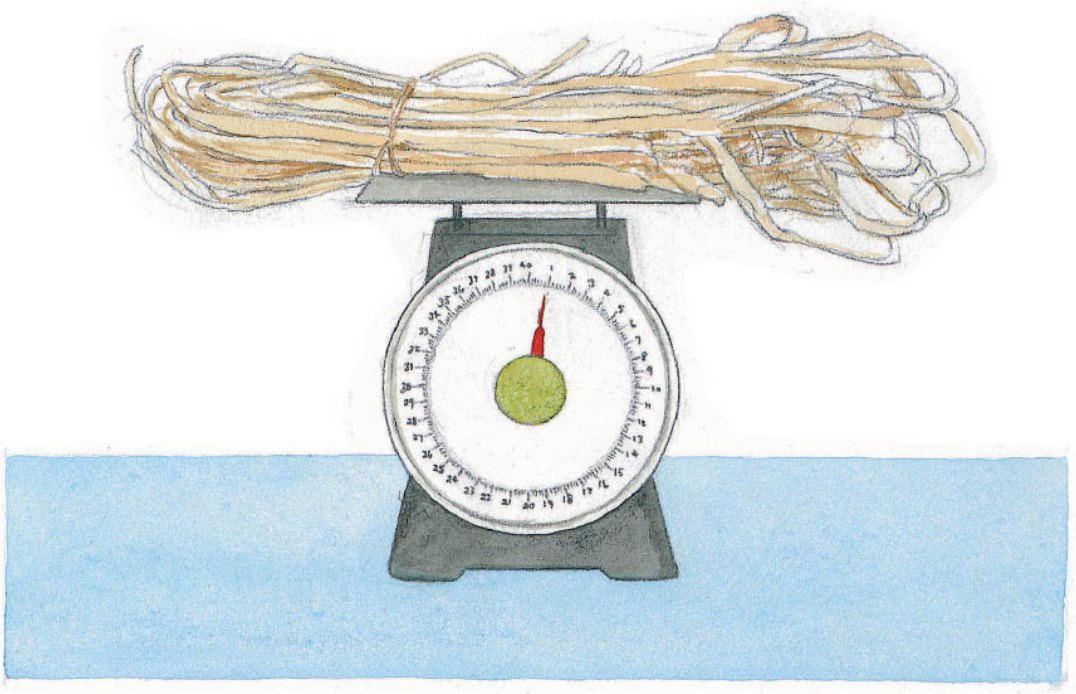
Strainer with mesh liner

Bucket

Rubber gloves

INSTRUCTIONS

1. **Weigh out your dry fiber.** Be sure to weigh out the fiber before wetting it — all measurements given are based on dry fiber weights. (If you do start with damp fiber that has never been dried, refer to Rose-of-Sharon or Yucca Paper, which include guidelines for how to measure alkali when using damp fiber.)



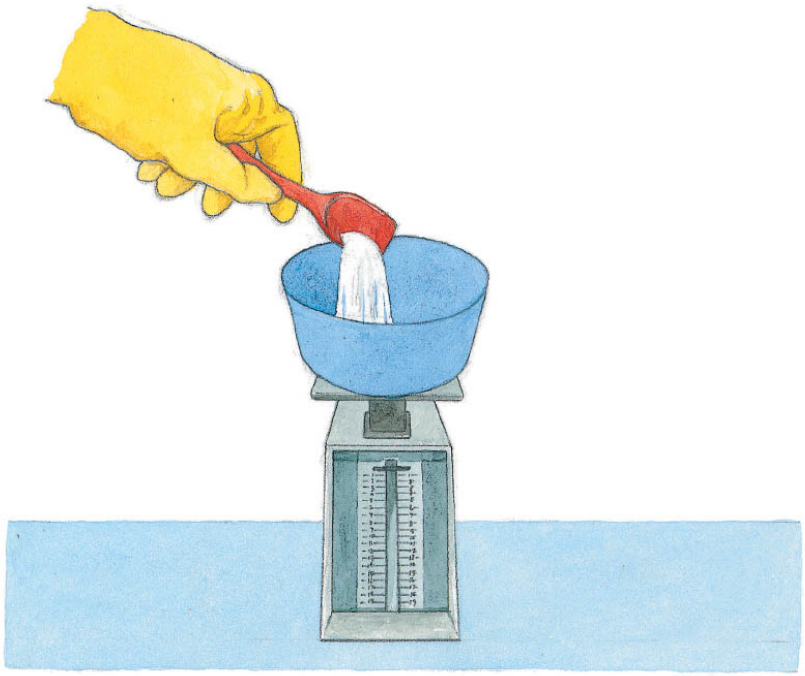
2. **Soak the fiber.** Before cooking the fiber, you must soak it in plain water. (Water will cause the cell walls of the fibers to swell, making them more receptive to even penetration by the alkali during cooking, and also will make the fiber sink into the cooking pot, which helps it cook evenly.) Put the fiber in a bucket, large bowl, or container and cover with water. Allow it to soak for a few hours or overnight. If some fiber floats to the top of the water, weight it down with a bowl or some other heavy object to ensure that all of the fiber absorbs some water.

   ➤ If you plan to beat your fiber in a blender or a hollander beater, you should cut it into ½-inch (1.25 cm) strips before soaking it, to prevent it from tangling. You can do this with a pair of scissors, although I find that my hand

tires quickly. I have an old paper cutter that I use to chop my fiber. Other papermakers use garden shredders.

3. **Measure the alkali.** Fill the pot with enough water to cover the soaked fiber — approximately 2 gallons (8 l) for 1 pound (500 kg) of fiber — but do not add the fiber yet. Wearing rubber gloves, weigh out the soda ash to make up 20 percent of the dry weight of the fiber. This means that per pound of fiber, you will need 3.5 ounces (100 g) of soda ash. This recipe is for an average cook and may need to be adjusted depending on the fiber you are cooking.

   ➤ Make sure there is enough water in the pot to cover the fiber so that it can move around when cooking — as when you're cooking pasta. You can add a little more water to cover the fiber if you need to.

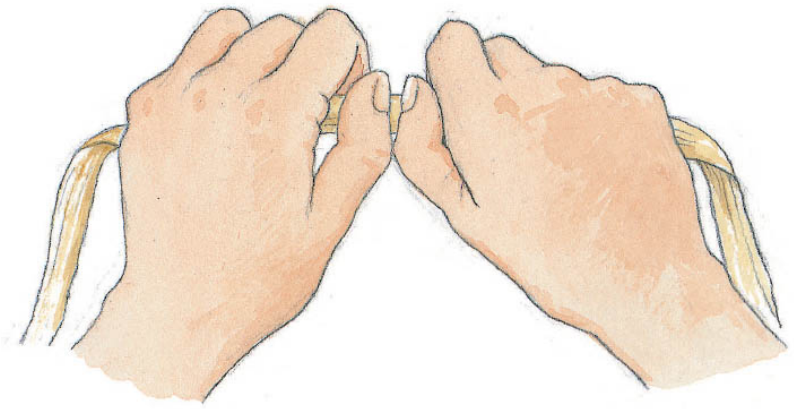


ABOVE: *Before measuring out the alkali, first place the empty container on the scale and set the scale back to zero so that you can get an accurate reading.*

4. **Add the soda ash and fiber.** Heat the pot of water and add the soda ash to the water just before it boils. After the soda ash dissolves (a matter of seconds), add the soaked fiber and stir it into the pot. Bring to a boil, then turn down the heat and simmer.

   ➤ The pH of the solution should measure between 10 and 11 (see here). If the pH is too low, add more soda ash, in very small amounts.

5. **Test for doneness.** Every ½ hour, turn the fiber in the pot by stirring and test it for doneness: Remove a piece of fiber from the pot, rinse it, and pull it in the direction of the plant's growth to see how easily the fibers can be pulled apart. A papermaker I know learned this method while studying in Korea. Grab the fiber with your thumbs and forefingers, with thumbtips touching. Using only the force exerted when you push your first thumb knuckles together, try to tear the fiber apart in the direction of the plant's growth. When the fibers tear easily — like cooked celery — they are done cooking. Try not to overcook the fiber — if it tears apart too easily, your sheets of paper will be weak.



6. **Rinse the fiber.** Turn off the heat and remove the pot from the stove. At this point, some papermakers let the fiber sit in the solution overnight to break it down a bit more. You can do this or proceed to wash the fiber. Pour the cooked fiber into a strainer, getting rid of the water and plant liquor (see the caution below). Rinse the fiber thoroughly, until the water running through it runs clear. It is very important to remove all of the soda ash at this point so that further breakdown of the fiber does not occur.

   If you want a very clean paper, you will now probably need to pick out bark and discolored specks by hand before beating. This is a common practice in Japan called *chiritori*.

   ➤ **Caution:** If you are not draining your water into a water treatment system, you should mix the plant liquor with vinegar to neutralize it before dumping it down the drain or outside. If you don't, you will release a toxin into the environment. Unless you are cooking with lye, the solution should be relatively mild.

Beating the Fiber

Individual papermaking fibers are long, slender shafts, only millimeters in length, with hairlike projections called fibrils. If enlarged, they might look like pipe cleaners. The fibrils are raised from the outer cell walls of cellulose and other fibers during beating. Beating roughens the fibrils and makes it possible for them to intertwine and form connections, or bond, and allows water to penetrate the walls of the fiber (called hydration). This bonding of the cellulose fibers is called hydrogen bonding, and it occurs during sheet formation as the hydrated cellulose fibers interlock.

Hand Beating

Many small-scale hand papermakers hand beat their fiber today. This method is particularly suitable for working with small amounts of material. Although it is labor intensive, it draws out the fibers, leaving them long, strong, and tenacious, and generally makes the strongest papers. You can hand beat your plant fiber using a mallet or a stout stick. Papermaking supply companies sell special mallets designed specifically for hand beating, but a baseball bat or a meat tenderizer will also do the trick. Just make sure the wood won't crack or wear down, because the residue will contaminate your plant material. Work on a hard, clean surface — like a piece of hardwood or Formica — that will not split or splinter.

Before you start beating, take a bit of the plant material and set it aside. As you beat, look at that sample to see how far you have progressed. After a while, you might think your efforts are fruitless, but when you compare some of your pounded pulp to that original clump, you will be able to measure your progress.

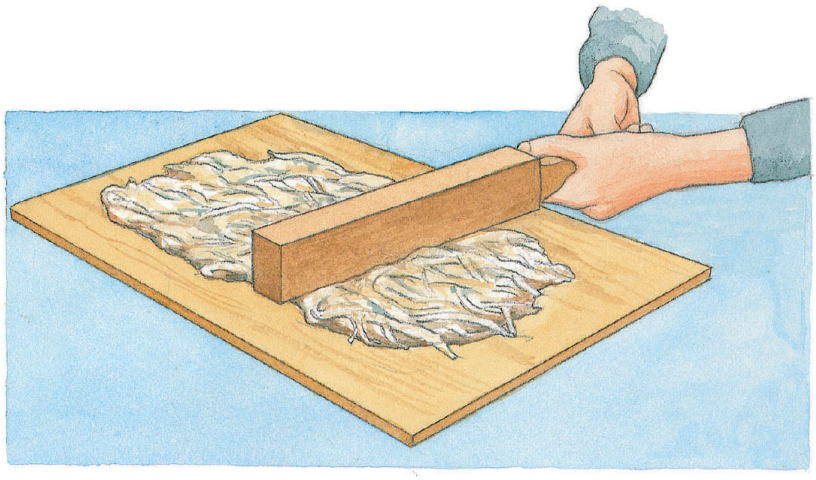
MATERIALS AND EQUIPMENT

- Cooked and rinsed plant material
- Mallet or bat
- Pounding surface
- Water
- Jar with lid
- Bucket

INSTRUCTIONS

1. **Press out the water.** Take a ball of pulp the size of a cantaloupe and squeeze out as much water as possible. You can press the water out in a small press if you have one, or you can squeeze it by hand. The pulp should not splatter when you start beating. If this happens, your fiber is still too wet.

2. **Beat until fibers are loosened.** Spread the mass of pulp out on your pounding surface (make sure the surface is clean). The initial beating loosens the fiber strands and spreads them out. Pound the lump with a bat or long stick. Use some force, but allow the weight of the stick to do most of the work. Starting at one end of the mass of pulp, move across it a stick's width at a time. When the fiber has spread out, fold the top, bottom, and sides up on themselves and start again. Beat for at least 15 minutes, until the plant material is thoroughly loosened.



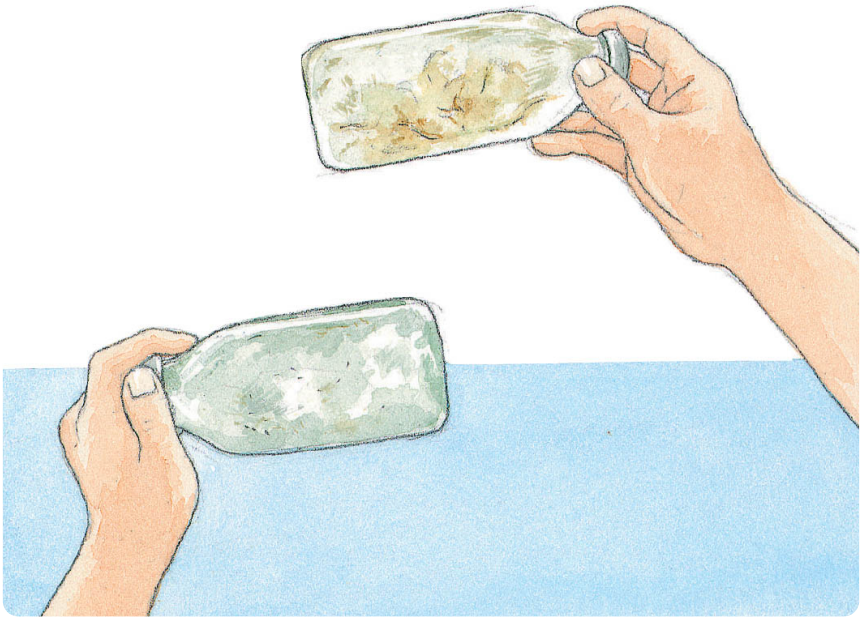
3. **Beat until fibers are completely separated.** At this point, you can switch to a hand mallet for more refined beating, but you can also continue with a stick or bat. Some people use two mallets — one in each hand. Add water to the pulp during this stage of beating. Sprinkle about ½ cup (125 ml) of water (this will vary according to the type of plant fiber) into the center of the mass, fold it up, and turn it over. Begin pounding. Beat the fibers directly against the pounding surface, spreading and flattening them as you work. Add water as the pulp dries out, folding up the mass and turning it over again. The batch of pulp will begin to look homogenous — a mass of tiny fibers lumped together. Beat for 15 minutes and perform the pulp test, described in the box below. Continue beating if necessary.

4. **Hydrate the pulp.** Once you've finished beating, place the pulp in a bucket of water and agitate it with a clean stick or paddle. Vigorous strokes will loosen the fibers in preparation for adding them to the vat. It's best to use your pulp right away, while it is fresh. However, if you are not

going to be making paper right away, do not hydrate the pulp. Simply store it in an airtight plastic bag in the refrigerator until you are ready to use it.

Pulp Test

This is a simple test to determine whether the fiber is done. Put a pinch of beaten pulp in a jar almost full of water and shake it up. If you see clumps and strings of fiber, it needs to be beaten longer. If the fibers do not clump and look very fine and uniform (sometimes invisible), the pulp is done.



Beating with a Blender

Another simple and inexpensive way to beat pulp is to use a blender. The blades of a blender actually cut the fibers, so the

resulting paper will have a different look than if it was hand beaten and it will not be quite as strong. Some papermakers start with hand beating, then finish with a quick spin in the blender. It is best not to use your kitchen blender — unless you want corn husks in your next milkshake.

The fiber should be cut into ½-inch (1.25 cm) pieces for blender beating. This can be done before the fiber is cooked, because it is easier to cut when dry, but you can cut it after you cook it, when it is wet. Cutting prevents the fiber from tangling in the blades of the blender. In addition to plant fibers, you can beat recycled papers in a blender — cut them into 2-inch (5 cm) squares.

MATERIALS AND EQUIPMENT

Blender Cooked and rinsed

Water plant material

Buckets

INSTRUCTIONS

1. **Beat by the handful.** Fill your blender three-quarters full with water and add a handful of pulp. Break up the pulp a bit so that it is not one big lump. Put the lid on the blender and turn it on. I usually start at a slow speed, like mix, and then switch to a higher speed when I hear that the blender is running smoothly (after about 10 seconds). If the motor sounds strained, turn it off and check that the fiber is not wrapped around the blades, or that there isn't too much fiber in the blender. The amount of blending time varies,

depending on the fiber and how coarse you want your paper to look. Onion skins will break down to pulp in just a few seconds, whereas iris leaves can be blended for a minute or more. Experiment with blending more or less to create finer or coarser paper.

2. **Remove pulp from blender.** Dump the freshly beaten pulp directly into your vat if you will be making paper right away. You can collect it in a bucket as well. Continue blending your pulp by the handful. If you will not be making paper right away, strain the pulp and store it in the refrigerator. Line your strainer with a fine mesh, like silk-screen mesh or mosquito netting (sold in camping stores) to make sure that you keep the tiny fibers from falling through the holes in your strainer.

Beating Aids

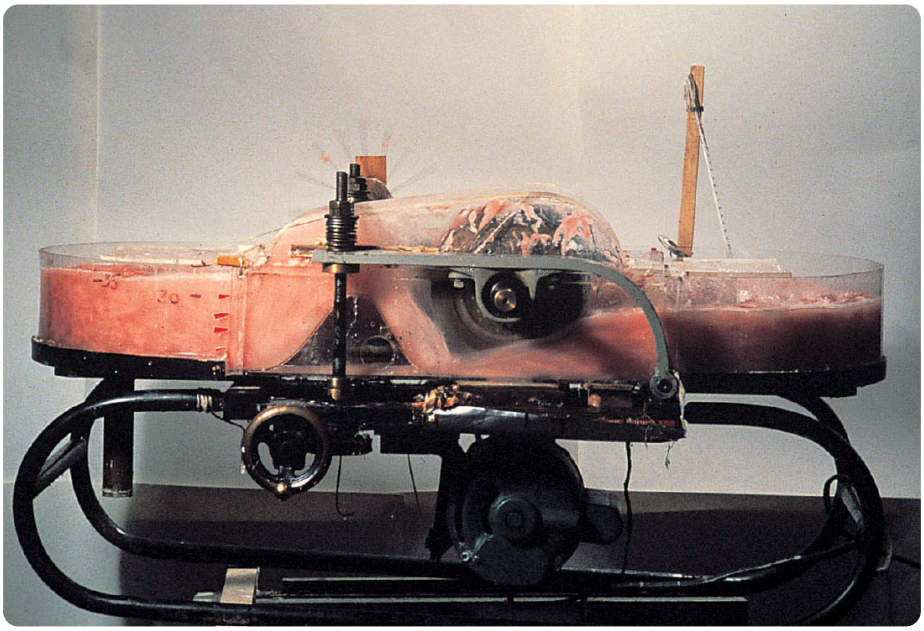
The first papers in China were ground by hand with a mortar and pestle. Other early papermakers simply pounded the fiber on flat surfaces with mallets. In Japan, such arduous hand beating led to the development of mechanically operated stampers. The first European stamping mills were powered by water. Because the advent of printing from movable type in the 15th century created a large demand for paper, stampers were redesigned and improved to increase production.

One of the ingenious alternative mechanical beaters is the Hollander beater, devised in the late 1600s in Holland. This machine greatly increased production and reduced the need to ferment cotton and linen rag fibers. A hollander beater is an oblong tub rounded at both ends. A roller with flat-ended blades sits in the tub, directly above a bedplate on the bottom of the tub. The fibers circulate in the water-filled tub and are macerated, shortened, and hydrated as they pass between the roll and bedplate. Hollander beaters are still in use today at most large-scale papermaking studios. They take up a fair amount of space and are quite expensive. Another type of mechanical beater is the Japanese *naginata* beater, which has rotating knives that do not shorten or cut the fibers. It is used after stamping to tease bast fibers apart.

There are several other beating aids, some traditional and others borrowed from other crafts or developed as inexpensive alternatives to the Hollander beater. Three of the most common ones are described on the next page. Most plant fibers can be beaten by hand or with a blender, but if you decide to set up a production facility, a larger machine will make your beating much easier and faster.

Although these are great time and energy savers for the serious papermaker, you do not need these machines to make the

papers described in this book.



Courtesy of Douglass Howell Estate

ABOVE: *A Hollander beater designed and built in 1961 by Douglass Howell*

- **The ball mill.** This machine is especially useful for beating long leaf fibers and some bast fibers. It is similar to a rock-polishing machine: The plant fibers are roughened and hydrated as they move between porcelain pebbles and the sides of a rotating jar. Ball mills are available through ceramic or lapidary suppliers. They are fairly expensive, beat a small amount of fiber at time, and are very noisy. You can find instructions for using the ball mill in Lilian Bell's book, Plant Fibers for Papermaking.

- **Stampers.** A stamper provided a mechanized system for pounding fibers, and treats them much the way hand beating would. Stampers are commonly used in Japanese papermaking,

since the long bast fibers need relatively little beating to be separated.

ABOVE: *A custom-built studio stamper designed and constructed by Harry Wold (see* Resource Guide*)*

- **Drill attachments and whiz mixers.** Drill attachments intended to mix paint also work well for breaking down sheet pulps like abaca and cotton linters. These attachments are not suitable for

preparing plant fibers, however, because they do not beat the pulp — they simply rehydrate already-beaten pulp. There is a contraption called a whiz mixer made just for papermaking, available from papermaking suppliers. You just fill up a garbage can with water, add sheet pulp, stick the end of the whiz mixer in the solution, and turn on the mixer. Drill attachments and whiz mixers can also be used to rehydrate plant fibers that have been stored in the refrigerator.

Additional Preparations for Bast and Leaf Fibers

Some plants require extra processing to separate the fiber from other parts of the plant before the fiber can be cooked and beaten. In woody and herbaceous bast fibers, for example, the inner bark, found between the woody core and the outer black bark of the tree, must be isolated by steaming and stripping before it can be cooked. Some leaf fibers, such as pineapple, contain long strings of fiber that must be removed from their fleshy outer skins prior to processing. The following techniques are standard methods for obtaining the fibrous plant material from these types of plants.

Retting

Tough leaf fibers and herbaceous bast fibers are difficult to break down just by cooking. This may lead you to overcook your fiber or cook it in too strong an alkali solution, which can destroy the fiber's integrity by breaking down the cellulose. Retting is a better

alternative. The process of retting allows fermentation of the plant fiber to occur, accomplishing two things: It loosens the cellulose from the noncellulose plant materials, and it breaks down the noncellulose materials, reducing or eliminating the need to cook the fiber. It is a way of letting nature help you prepare your fiber, and can be as simple as leaving your plants out in the backyard or as complex as soaking them in an alkaline solution and monitoring the pH.

Field Retting

Perhaps the simplest form of retting is field, or dew, retting: exposing the plants to weather (dew, sun, rain, and air) after harvesting. Eventually, the noncellulose components will deteriorate, leaving behind the cellulose you need.

One papermaker in Minnesota noticed that nesting birds in his field were easily pulling the bast fibers off the nettle plants he had left standing in his field all winter. He realized that he did not need to do all of the work he had done in fall — cutting the stalks and steaming them to loosen the fibers. If he waited until spring, he could just peel the fibers right off the plant. You can also harvest the plants and lay them outside on the ground to ferment.

Water Retting

Another form of retting is water retting, in which fermentation takes place when you leave the fiber in standing water in a warm place until bacterial action softens the fleshy plant material and makes it easy to remove. Depending on the fiber and temperature, this can take weeks or months. One papermaker from Arizona soaks his yucca leaves for 2 months before he cooks them. (He pounds them with a mallet first to break the skin and allow water

to penetrate the fiber.) A Florida papermaker puts her fiber in garbage barrels and sets them outside on the south side of her studio; the temperature rises to over 100°F during the summer, and the nonfibrous material rots away. Retting fiber smells like spoiled milk, and this papermaker notes that she is lucky to be located downwind from her neighbors.

To ret your fiber in water, place the plant material in a bucket and fill it with water. Place mesh or screen on top to keep bugs out and cover it to block out light, but do not seal it completely from air. This process can take as little as a week, but it can also take months. The warmer the temperature, the faster the fermentation. Stir your fiber *daily* and monitor it every day after the first week to avoid overfermentation. Although your fiber will smell, you must stir it, because oxygen needs to be mixed into the solution for bacterial action to occur.

➤ Adding milk to the water will accelerate fermentation — use about 8 ounces (240 ml) of milk per 5 quarts (5 l) of water.

To test your fiber for doneness, remove a piece and gently tug it on its long axis. When it pulls apart, it is done. It is possible to ret too long and damage the fiber, so this test is important. When done, remove the fiber from the water and rinse it thoroughly to stop fermentation.

ABOVE: *Cutaway of a barrel being used to ret fiber in water*

Alkaline Soak Retting

You can also soak fiber in the lye of wood ash or lime to soften it. For thorough documentation on this type of retting, including how to monitor it using pH tests, refer to Winifred Lutz's appendix in *Japanese Papermaking*.

Extra Herbaceous and Woody Bast Fiber Preparation

Steaming, stripping, and cleaning are required for most herbaceous and woody bast fibers prior to cooking (excluding most petiole bast, which does not require further processing and can be peeled right from the plant). Some herbaceous plants can be retted to eliminate some of the following steps (see Retting). All of these steps must be followed for woody bast fibers.

Steaming

The first step in processing an herbaceous or woody bast fiber is to separate the inner bark (bast) from the outer bark and woody core, if there is one. With some plants, such as willow, elm, and gampi, this can actually be done right after harvesting, but most plants require steaming to facilitate removal.

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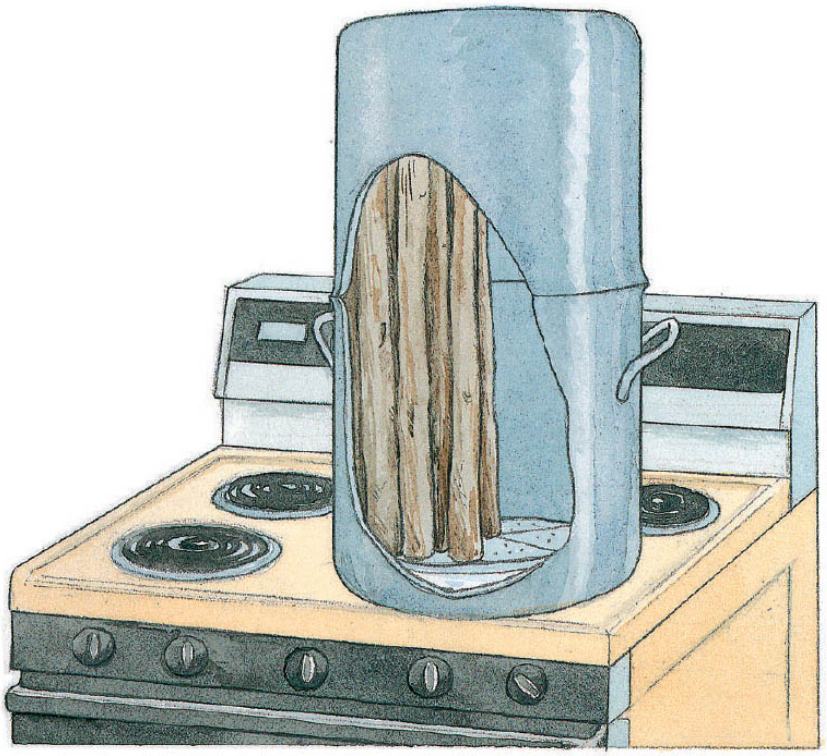
1. Cut the stalks into lengths that will fit in a large covered pot, leaving them as long as you can. If you have two pots that are approximately the same size, you can use one as a lid by putting it upside down on top of the other, thus allowing for longer stalk lengths. Otherwise, you can make an aluminum foil tent to cover the stalks. Place a vegetable steamer in the bottom of the pot and fill with approximately 2 inches (5 cm) of water. Place the stalks in the pot vertically. Cover tightly with a lid.



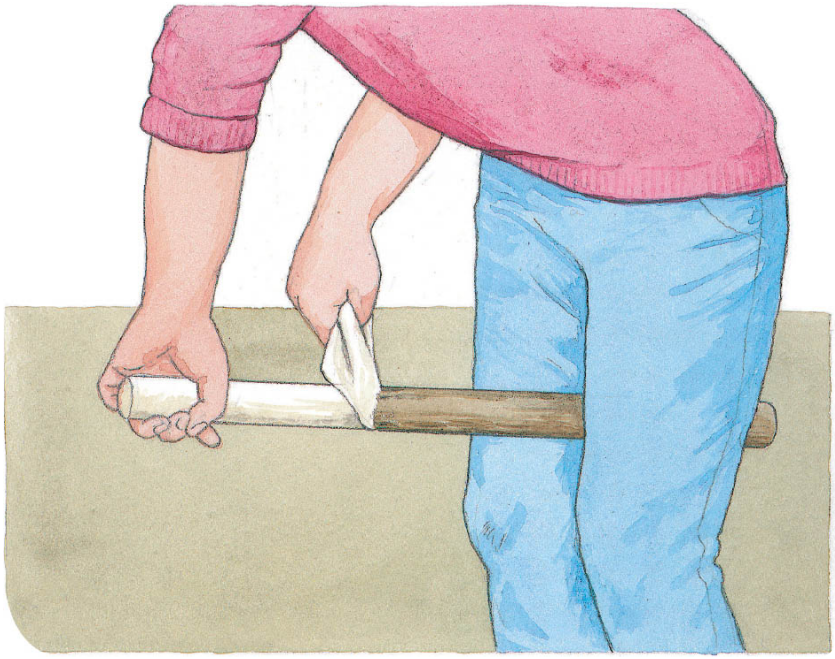
ABOVE: *Cutaway view of steaming process*

2. Bring the pot to a boil and steam the fiber until you can see the bark shrinking from the end of the wood — this will be obvious, and can take anywhere from ½ hour to 2 hours. Turn off the heat.

Stripping

3. As soon as you can handle the bark, begin to strip the inner bark from the woody core of the plant while it is still warm. Take a branch and make a vertical slit at the bottom of the stalk (the wider end) and pull enough away from the core to get the entire stalk's inner and outer bark in your hand. Holding this firmly, pull the bark off the woody core at a severe angle. With some plants, this will make the outer bark fleck off — saving you from having to scrape it off later.

   ➤ Stripping from the wider base toward the narrower end of the branch will help you remove the entire inner bark in one pull.



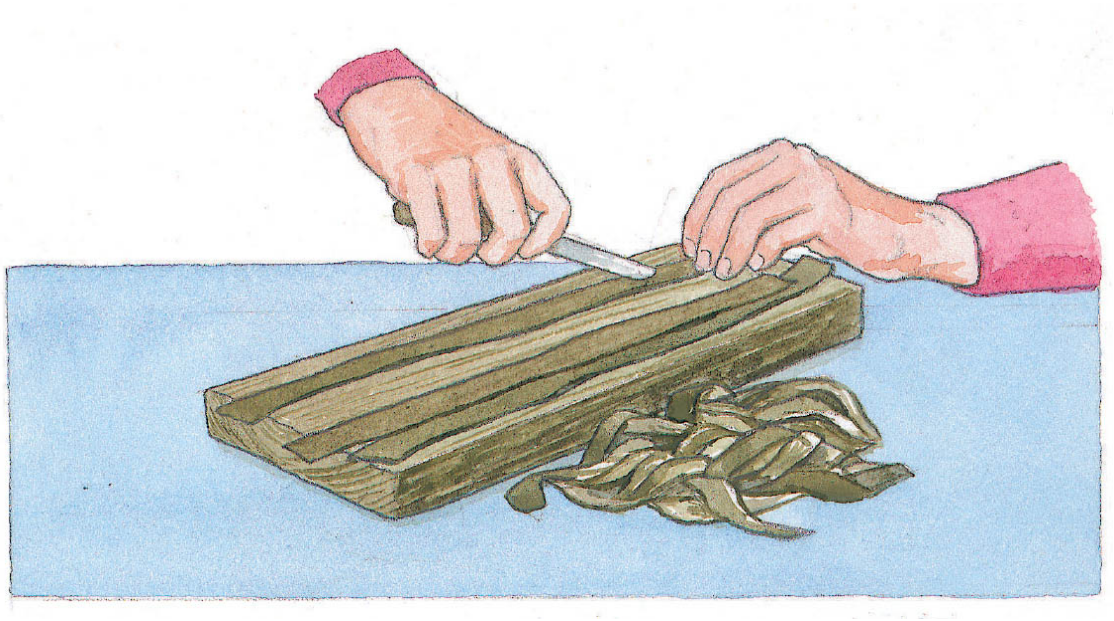
Cleaning

4. If the outer bark was not removed during the stripping process, you will need to scrape it off the inner bark now. Even if the outer bark fell off during stripping, there is probably some remaining black bark that you could remove. Scraping off the outer bark ensures that your paper will turn out pure and consistent, because it enables the fiber to be properly separated during beating.

The inner bark must be wet to facilitate scraping. If dried, soak it in water for at least an hour. Take one piece of bark at a time and, using a blunt knife or other scraping tool, scrape the fiber against a hard surface. Start at the wider end of the bark and scrape from the base toward the top.

➤ You may see several layers of inner bark in some plants. Fig (Ficus spp.), for example, has both a white and a green

inner bark. The white is purer, and you can separate it from the green bark to make a finer paper, or combine it with the green bark, which is also fibrous.



5. Wash the stripped bark in clear water and pick out any remaining specks of bark. At this point, you may proceed with cooking the fiber or hang it to dry, then bundle and store it until you are ready to make paper. Store it in a dry place with air circulation (see here).

ABOVE: *Papers made with fig fiber scraped to varying degrees*

Decorticating Leaf Fibers

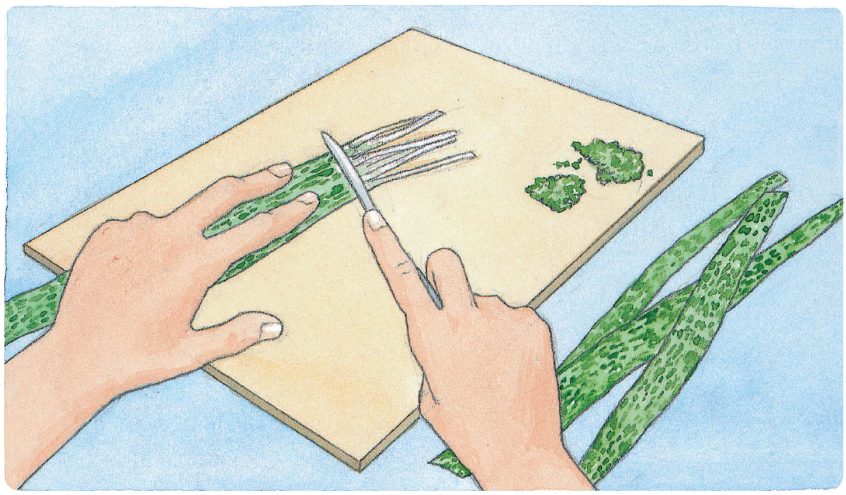
Leaf fibers like yucca, sisal, agave *(Agave salmiana),* and pineapple *(Ananas bracteatus* or *A. comosus)* that have long fishing-line-like fibers are difficult to process and might require the use of a Hollander beater. However, this stringy fiber must be separated from the fleshy green plant matter before the fiber can be cooked and beaten. This process, called decortication, is often tedious, but can be aided by retting (see here) or by using a

decorticating machine. Once you have obtained the stringy fibers, proceed to cooking.

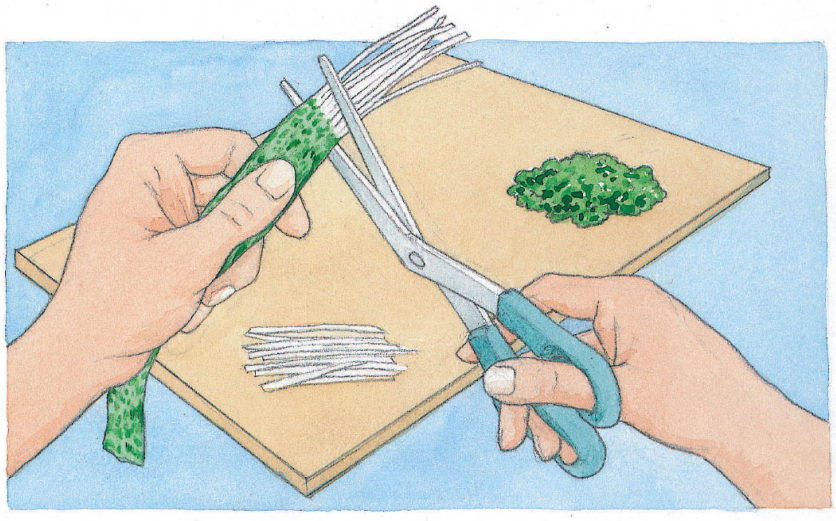
One method of decortication is to scrape the fleshy plant material off with a knife or other scraping implement. I've found that pounding the leaves with a meat tenderizer and soaking them in water for a couple of hours before scraping can ease the process. Again, however, this process can be tedious, and if you are interested in producing quantities of this type of paper, you will probably want to ret it or find a mechanical device that can help you decorticate.

ABOVE: *When held up to a light, this sheet of paper made from pineapple fiber reveals the long, stringy fibers that must be decorticated from the pineapple leaf.*

1. Work on a hard, clean surface that isn't too slippery, such as a cutting board, and scrape one leaf at a time. Start at the tip of the leaf and scrape in 3-inch (7.5 cm) sections.



2. After removing the fleshy material from the top 3 inches (7.5 cm), cut the scraped strings off the leaf and start a new 3-inch (7.5 cm) section. I do it this way because I've found that it is almost impossible to scrape the entire leaf — the strands get tangled.



Embellishing and Protecting Paper with Additives

There are a few additives that can be added to your papers to color, coat, or protect them from elements in the environment that cause deterioration. These additives are not necessary, but they can change the quality of your pulp and enhance your papers.

Sizing

Sizing coats the fibers and makes them more water repellent and bleed resistant, so that you can watercolor, work with ink, or print on the finished sheets. Internal sizing is added to pulp at the end of the beating cycle, prior to sheet formation, and is already in the paper as it is formed. Synthetic internal sizings (alkylketen dimers) are pH neutral, and are available from papermaking suppliers in liquid form. If you hand beat or process your pulp in a blender, disperse your entire batch of pulp in a bucket of water and add sizing according to the supplier's directions. Then dilute your pulp with more water in the vat for sheet formation.

Surface sizing can be applied to papers after they are formed into sheets. Surface sizing adds an additional layer of protection against contaminants in the air. Traditionally used throughout Asia and Europe, surface sizing may have contributed to the permanence and durability of many historical papers. See instructions on surface sizing.

Buffers, Brighteners, and Fillers

These additives can make your paper smoother, more opaque, and more resilient to environmental conditions that cause degradation. There are many different kinds of buffers, brighteners, and fillers (some of the most common are listed below) that can be purchased from the papermaking, ceramic, and art-supply stores and they come with instructions for use. They should be added to the pulp at the end of the beating cycle — add enough to treat your entire batch of pulp at one time.

Common Buffers, Brighteners, and Fillers

ADDITIVE	DESCRIPTION	FUNCTION	EFFECT ON PAPER FINISH
Calcium carbonate (CaC03)	powder	protectant, filler	Protects paper from acidic contaminants in the air by slightly increasing the paper's alkalinity; also acts as a filler — filling in the subtle crevices between the fibers — making sheets of paper more even and opaque
China clay, or kaolin	powder	buffer	Makes paper more opaque and smooth

ADDITIVE	DESCRIPTION	FUNCTION	EFFECT ON PAPER FINISH
Titanium dioxide	white pigment	buffer, brightener	Makes paper whiter; also makes it more opaque and smooth

Coloring Pulp

My personal preference is to work with the natural color of a plant fiber to enhance its inherent beauty. A range of colors can be had without any additives, from the golden sheen of a sheet made with wheat straw to the rich red-brown of a sheet made from onion skins. Qualities of each plant fiber add a unique character to the sheets of paper made from them.

However, there are also methods of coloring your paper if you prefer. The two main coloring agents available are pigments and dyes.

Color permanence is of great concern to most papermakers, and there are several factors to consider.

- The color should be durable and should not rub off when touched.
- The color should not bleed if the paper needs to be dampened.
- The colorant should not lead to deterioration of the paper.
- The color should not fade after long-term exposure to light.

All of these factors might not be important for every sheet of paper, but usually some of them are. In general, pigments are more permanent than dyes, especially in terms of light-fastness, and are the colorants most typically used by hand papermakers.

➤ ***Note:*** A thorough and detailed analysis of the various coloring agents, including several recipes, can be found in Elaine Koretsky's book, Color for the Hand Papermaker (see Reading List).

Working Safely

- Wear a mask when working with dry pigments or dyes. The dustlike particles of dry pigments and dyes are common irritants that can cause rashes, nausea, and headaches.
- Wear gloves. Many pigments contain heavy metals, which are toxic and can be absorbed by the skin.
- Do not use pigmenting or dyeing equipment for cooking food, and do not work in an area where you prepare food.
- Store your pigments safely, away from children, and label everything!
- Wash your hands after using pigments and dyes.

Pigments

Pigments are insoluble particles that, when added to pulp, do not naturally attach themselves to the fiber. They must be physically attached to the fiber with a retention agent. The retention agent is a cationic (made up of positively charged ions) substance that gives the pulp a positive charge. Pigments tend to have a negative charge. Because postive and negative charges attract, the

negatively charged pigment will bond itself to the positively charged pulp if the proper amount of retention agent is added.

Pigments are mixed with various dispersing agents for a variety of art media. They are mixed with linseed oil to make oil paint, ground with an acrylic emulsion to make acrylic paint, and ground with gum arabic or other binders to make inks and watercolors. Pigments mixed with water are called *aqueous dispersed pigments* and these are the ones used for papermaking. Aqueous dispersed pigments are available from papermaking suppliers and some art stores; they're safe and easy to use.

Making your own pigment. You can make your own aqueous dispersed pigments using dry powder pigments, which come in a wide variety of colors, but use caution. Wear a mask and gloves when working — many dry pigments are toxic and should not be absorbed by the skin or inhaled. To mix, disperse the pigment in enough water to make a thick paste (a few drops of water per tablespoon of dry pigment), and finely grind it in a mortar and pestle. When adding this to pulp, strain it through a fine mesh (such as silk screen) to remove any particles that are still present.

Tips and tricks for adding pigment. Aqueous dispersed pigments purchased from papermaking suppliers come with adequate instructions, but there are a few things worth mentioning. As with dry pigments, add a little color at a time and strain your pigment through a fine mesh, like silkscreen, to prevent any particles from getting into the pulp and forming blobs of color. Once you have added the pigment, check the color of the water — it will probably have some color in it. A properly pigmented pulp has clear water, which means that all of the pigment has attached to the pulp. If the water is not clear, you need to add retention

agent. Some papermaking suppliers suggest adding retention aid before you add the pigment, and others tell you to add it after pigmenting. I prefer to get a satisfying hue and intensity of pulp before I add retention aid, but I don't think there is a right or wrong method.

➤ Some sizings give the pulp a positive charge and act as retention agents themselves, so you may not need additional retention aid if you use sizing.

Nontoxic Pigments

I have had success using tempera paints to pigment pulp. I use them when I'm working with children because they are nontoxic. I usually start with a container full of pulp, add a few squirts of tempera, and mix it up. I continue adding paint until the pulp reaches my desired color. Then I check the water for clearness; if it isn't clear, I add a few drops of retention aid and mix it again until the water is clear.

Helen Hiebert

ABOVE: *Dry powder pigments are available in a wide range of colors.*

ABOVE: *Prepared aqueous dispersed pigments, such as those shown on the middle shelf, can get messy, so when storing them, choose a place that can be spattered and dripped on.*

Synthetic Dyes

Dyes are soluble substances that penetrate the fiber structure and chemically attach to the cellulose molecules. Because they penetrate the fiber, they actually become a part of the material. Most dyes are not light-fast (that is, they fade when exposed to

light). There are many types of synthetic dyes used in the paper and textile industries; for a complete description, check out *Color for the Hand Papermaker* by Elaine Koretsky (see "Reading List"). Two types of dyes that are useful to the hand papermaker are direct dyes and fiber-reactive dyes. Direct dyes are easy to use and come in a wide range of colors. They are sold in powder form and are available in grocery or art-supply stores. Fiber-reactive dyes also come in a wide range of colors, and they'll create very deep shades of color. They form a stronger chemical bond with cellulose than do direct dyes, and they are somewhat more light-fast than direct dyes.

➤ Direct and fiber-reactive dyes react with the fiber and the water, so considerable rinsing is required to remove the dye from the water.

ABOVE: *synthetically dyed papers*

ABOVE: *1 THROUGH 4: Kenaf (Hibiscus cannabinus) with fiber-reactive dyes; 5: Banana fiber paper dyed with a fiber-reactive dye*

Natural Dyes

Many natural dyes are plants found in your kitchen or garden. Other natural substances can also be used for dyeing, such as cochineal and lac (produced from the bodies of insects). Although many natural dyes are not light-fast, you can obtain hues with them that are not found in synthetic pigments and dyes.

Most natural dyes require the use of mordants (chemicals that fix the dye in or on a substance by combining with the dye to form an insoluble compound). Commonly used mordants include many kinds of metallic salts, such as alum, chrome, tin, iron, and copper, and tannic acid. However, these mordants can react with the cellulose in the paper and cause deterioration. You can try using retention aid as a mordant instead.

NATURAL DYE MATERIALS

Black walnut husks	Logwood
Brazilwood	Marigold
Cochineal	Osage orange
Coffee grounds	Safflower
Cutch	Suo
Enju	Tea leaves
Indigo	Turmeric
Lac	

ABOVE: *naturally dyed papers*

ABOVE: *See chart below of the fibers and dyes Elaine Koretsky used to make these sheets.*

Making Your Own Natural Dye

The natural dyes listed to the left can be found in your garden or at weaving supply stores. Some of them will just tint the paper, and others can be deepened by the use of retention aid or other mordants. The colors that they impart to your paper can vary, depending on what type of retention aid or mordant you use (and even whether or not you choose to use them). These are simply general instructions for making natural dye as described in *Color for the Hand Papermaker*, by Elaine Koretsky — please refer to her book for specific recipes and to chapter 5 for instructions on making a dye from black walnut husks.

INSTRUCTIONS

1. Gather 2 quarts (2 l) of the plant material you wish to use as a dye. Wash thoroughly and cut it into pieces. Put it in a pot, cover it with water, and let it soak for a few hours.
2. Bring the pot to a boil and simmer for 1 hour. Then strain out the plant material. The remaining liquid is the dye bath, or dye liquor. 1 to 2 quarts (1 to 2 l) of liquid will dye approximately 3 ½ ounces (100 g) of dry fiber.
3. Beat 3 ½ ounces (100 g) of paper pulp and then strain out the water. Add the pulp to the dye liquor and mix well. Simmer the pulp in the dye bath for 1 hour, then let it cool in the liquid. Check to see if pulp has retained the colorant. If not, add retention aid.
4. Drain and rinse the pulp and rehydrate or beat it again as necessary.

Natural Dyeing Samples

PAPER	FIBER	DYE	ADDITIVES
A	Manila hemp	suo	alum, copper sulphate, retention agent
B	Daphne	indigo (4 dippings of the pulp)	retention agent (plus soda ash and sodium hydrosulphite used in indigo dye bath)
C	Mitsumata	enju	retention agent
D	Manila hemp	logwood	stannous chloride
E	Mitsumata	logwood	potassium dichromate
F	Manila hemp	marigold blossoms	stannous chloride, retention agent
G	Manila hemp	indigo	soda ash and sodium hydrosulphite used in indigo dye bath
H	Gampi	safflower	soda ash, lemon juice, retention agent

Black Walnut and Indigo Dyes

When Bridget O'Malley was working as an assistant to Timothy Barrett at the University of Iowa's paper facility, a student did a papermaking project using the husks of the black walnuts from

a tree there to dye some of her paper. When Bridget and Tim saw it they were amazed by the rich color. They couldn't get a similar color with the pigments they were using. Bridget began collecting walnuts and experimenting with the new dye material. She brushed the solution onto sheets, put it in wet pulp, and tried using different concentrations to vary the color.

One day, when brushing the dye onto a paper's surface, she accidentally grabbed a sheet of paper that had been sized with gelatin and noticed that it wasn't absorbing the dye in the same way. She also noticed that the dye seeped into creases in the paper, forming darker lines that looked similar to batik. She liked the effect and decided to re-create it, naming the result O'Malley Crackle (2). Bridget moved to Minnesota and she and her business partner, Amanda Degener (the two co-own Cave Paper), began experimenting with indigo as a dye. Eventually, they came up with their Layered Indigo Flax (1), another discovery made when playing around in a shallow vat that didn't allow for the entire sheet to be dipped at one time. They pushed this idea and came up with a beautiful paper covered with striations and landscape patterns.

A third paper was developed after the pair read about the history of dyes and discovered that indigo and walnut had once been used together to make black cloth. Naturally, they had to try it, and they developed their rich Black Flax paper (3). All three of these unique papers are produced at Cave Paper in Minneapolis.

1
2
3

Keeping a Detailed Record: Part II

Fiber-Preparation Record

Precooking preparation: Cut into ½-inch pieces and soak overnight in plain water.

Did you ret, steam, strip, or scrape the fiber prior to cooking? Did you cut it in preparation for beating it in a blender? How long did you soak it? Did you soak it in water or an alkaline solution?

Alkali: Soda ash

Alkali weight: 1.6 ounces (45 g) — 20% of dry weight of fiber

Which alkali did you use? How much did you use? What percentage of the dry fiber weight did you use?

Volume of water: Did not measure; covered fiber in a 3-gallon (11 l) pot

How much water did you have in the cooking pot?

Time: 1 ¾ hours

How long did you cook the fiber?

Cooking comments: I was pressed for time, and I might have cooked a bit longer if I had the time. I let the fiber sit in the cooking solution for 2 hours before rinsing.

Record any observations you had of the cooking process.

Rinsing: ½ hour in bucket in bathtub under running water; covered fiber with mesh to prevent it from floating out of bucket.

How and for how long did you rinse the plant material?

Beating: Blender

Volume of water: Three-quarters of a blenderful per handful of pulp

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Time: 1 minute per handful

How did you beat the pulp — by hand? By blender? How much water did you add? How long did you beat it for?

Additives: None

Did you add sizing, buffering agent, pigments?

Beating comments: None

Record any observations you had of the beating process.

Fiber Storage: Used immediately

Did you store the fiber in the refrigerator or in buckets for a few days?

CHAPTER 4

Making Paper

By now you have discovered that there are several steps involved in making a sheet of paper, and a minor step in the process is the actual making of the sheet! The fiber selection, cooking, and beating are at least as important as, if not more important than, the physical act of forming and finishing sheets of paper. You might think dipping a sheet is quite simple, but there are many subtle things you can do to perfect your papermaking. What follows is a step-by-step guide to making, pressing, and drying a sheet of paper, including a troubleshooting guide to help you fix common mistakes.

Choosing a Papermaking Style

There are three common methods of sheet formation used in this country. The Western or European technique originated in Europe and was the first technique used in the United States. Western papermaking involves dipping a mould and deckle into a vat of pulp and pulling a sheet of paper. Asian, or Eastern, papermaking is an older technique that utilizes a bamboo screen, which is similar to the mould and deckle but

flexible. The techniques used throughout Asia differ slightly, and I will refer to the Japanese papermaking technique throughout this book. A contemporary adaptation of the Nepalese style of papermaking utilizes the deckle box, which was probably the earliest tool used for papermaking and is still in use in Nepal and other countries today. The deckle box does not require dipping into a vat at all. It is a type of mould and deckle you can use if you have very little pulp, if you want to make a very thick sheet of paper, or if you want to mix pulps together.

Choosing which method to use can depend on the fiber you're using, the amount of pulp you have, and the look that you desire. Even if you used the same batch of pulp, each method would produce a slightly different sheet. In many cases, choosing a papermaking method may just come down to which one suits your personal expertise and preference. Since this chapter will discuss each of these techniques in detail, I recommend that you read it entirely before you start, to help you decide which to use.

Handling Pulp

Be careful when handling your pulp. It is in its freshest and best state right after beating. Avoid creating knots and clumps, which will end up as impurities in your sheets of paper. Keep the pulp suspended in water, and take care to keep bits of dried pulp from collecting on the sides of

buckets or vats by continually spraying them down with a hose.

Western Papermaking

The Western technique works particularly well for making paper with short fibers, such as grass, which bond easily in a single dip. Although it is suitable for most longer fibers as well, in some cases these long fibers tend to tangle and form knots in sheets of paper. If you are having this problem, you might want to try the Japanese method.

Step-by-Step Sheet Formation

The ratio of pulp to water in your vat is the main determinant of the thickness of your sheets of paper. If you want to make thick sheets of paper, you will need more pulp and less water. For thinner sheets, you need more water and less pulp.

Filling the Vat

1. When you're using hand-beaten pulp, first disperse the pulp in a water-filled bucket and stir it vigorously so that the individual fibers are loosely suspended. Then fill the vat by adding a few inches of water followed by a few cups of watery pulp.

➤ When I work with a blender, I sometimes pour freshly mixed blenderfuls right into the vat until I get the proper consistency.

2. Agitate again to evenly disperse the fibers in the vat, and then pull a test sheet of paper to determine whether it is the proper consistency. If it's too thin, add more pulp and pull another test sheet until you get the desired thickness.

➤ Add pulp gradually, keeping in mind that it is easier to add pulp than it is to remove it.

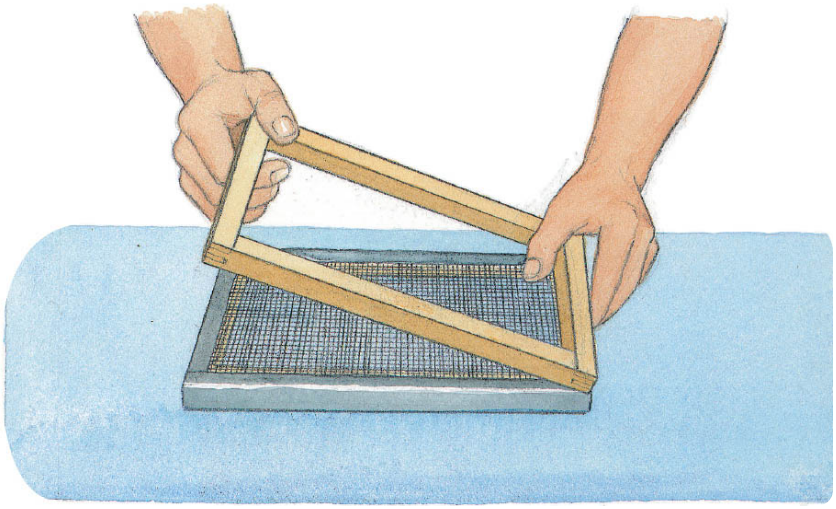
Hogging the Vat

3. Pulp tends to settle to the bottom of the vat, so it needs to be agitated to evenly disperse it prior to pulling a sheet. You must "hog" the vat: Stick your hand into the slurry of pulp and water and vigorously mix it. The vat should be hogged each time you make a sheet.

Pulling a Sheet

4. Wet the mould and deckle before you pull the first sheet. This will prevent the fresh sheet of paper from sticking to the mould or deckle during the couching process and allow water to drain through the screen evenly, which aids in even sheet formation. Spray it with a hose or run it under a sink. (It is not necessary to repeat this process, since the mould and deckle will be wet after the first sheet.)

5. Hold the mould with the screen side facing up and place the deckle on top, making sure that all edges and corners line up.



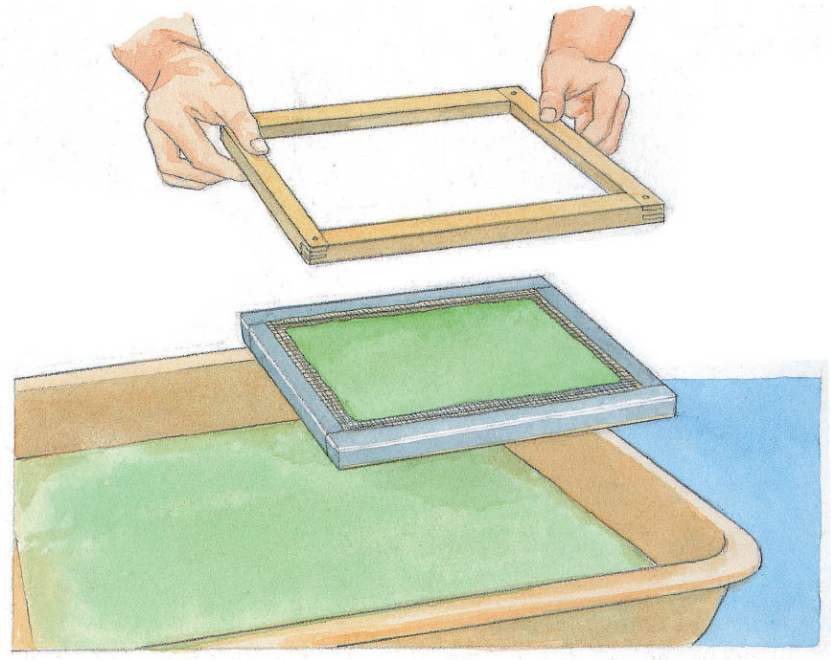
6. There are many ways to pull a sheet of paper — each papermaker has his or her own technique. This is my Western-style technique. The following sequence should take place in one fluid motion:

   - Dip the mould and deckle into the vat at a 45-degree angle to the bottom of the vat, scooping underneath the surface of the pulp and pulling toward yourself.

- Bring the mould and deckle parallel to the bottom of the vat, lift them up out of the mixture, and shake — left and right and back to front — with semivigorous motions, as if you were a prospector panning for gold. Shaking interlocks the fibers and distributes them evenly on the mould, making the sheet of paper uniform in thickness. The sheet of paper is being formed as the pulp settles on the screen.
- Shake until the fibers start to settle on the screen as the water drains, but do not shake too long. If you continue to shake once the fibers have started to settle, you will damage the sheet.

7. When you see that the fibers have settled on the screen, balance the mould and deckle on the corner of the vat and remove the deckle. Take care not to drip water from the deckle onto the freshly made sheet (these drips

become “papermakers tears” — see here). This can be accomplished by gently whisking the deckle over the mould while you keep it parallel to the deckle. If there is fiber on the edges of the mould, gently brush it back into the vat with your fingers. This helps keep your felts clean. Set the deckle to the side, or drop it into the vat to rinse it off.



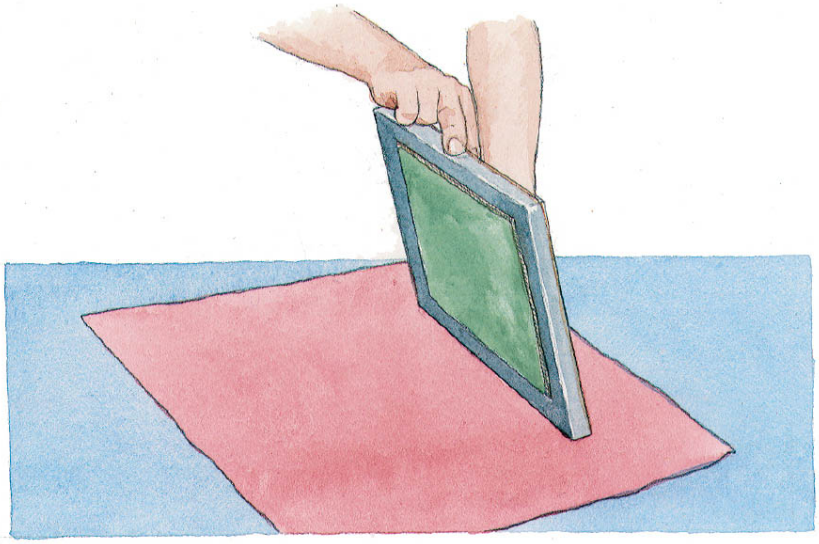
8. Gently tilt the mould and watch to see that the sheet on the surface does not start to slip. If it does, return it to the horizontal position and continue to drain. When you are able to tilt it, hold it at an angle with one corner pointing into the vat, letting a stream of water drip from the corner until it slows to a trickle.

Couching

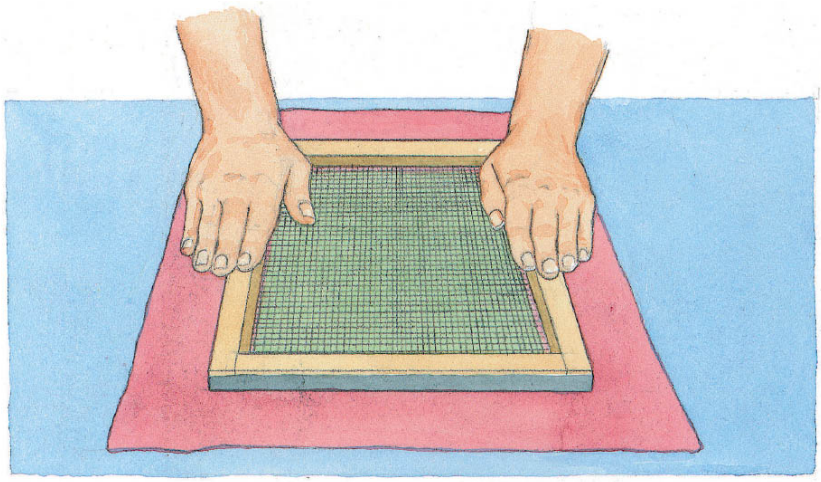
The term *couch* (rhymes with pooch) comes from the French verb *coucher,* which means “to lay down.” Couching is a fluid, rolling action. You lay the sheet down from one side, press briefly, then roll the mould up and remove it from the felt. Once a cushion of sheets has been formed, you can press during the roll and just lift the mould right up. Some papermakers have couching stands that are curved to enhance the couching roll.

9. Dampen a felt and smooth it out in the couching tray. The dampness helps you release the sheet of paper from the mould. As a significant amount of moisture will build up in the pile, called the post, subsequent felts may not need to be dampened.

10. Set the driest edge (the top edge as you were draining) of the mould down on one edge of the felt, with the wet sheet facing the felt. Holding the mould in the center of both long sides, lay it down so that the entire mould is flat on the felt.

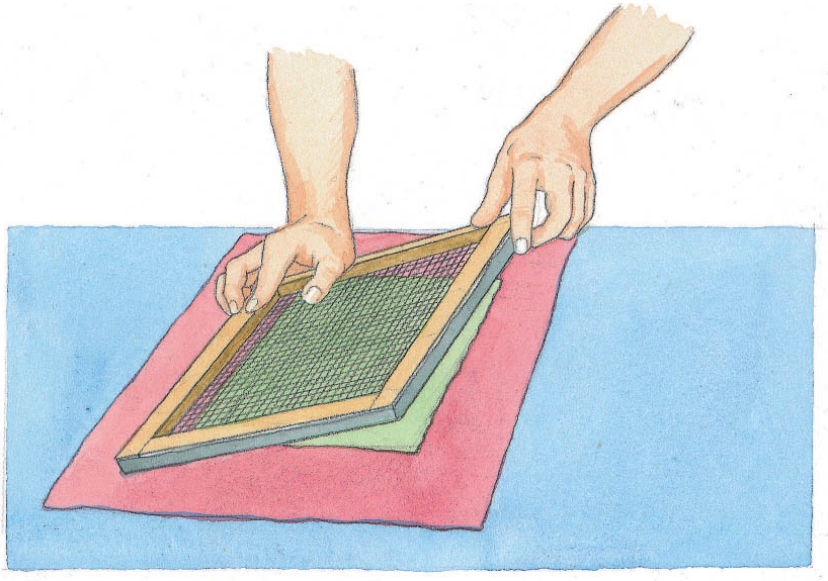


11. Apply even pressure to the back of the mould's edges and screen, to ensure that the sheet transfers to the felt. You should see a little water come up through the back of the mould.

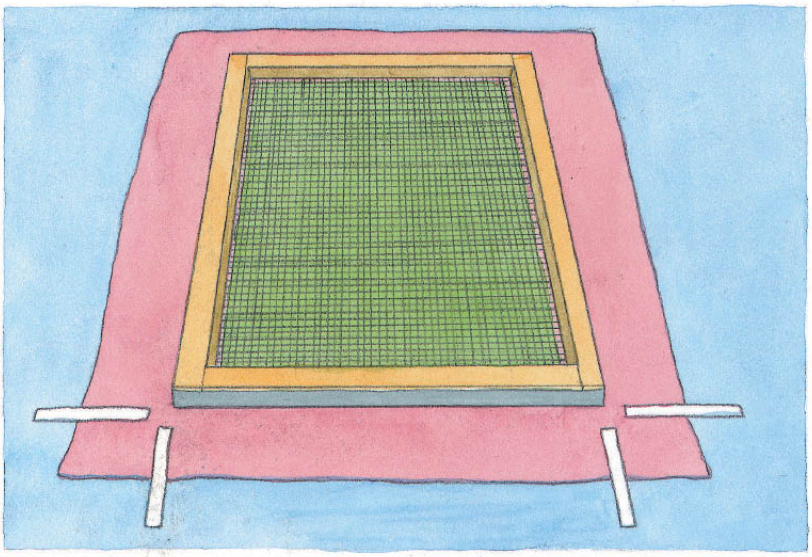


12. Lift the edge of the mould that you set down first, peeking underneath to see that the sheet has released

(see Troubleshooting if it hasn't), and remove the mould, taking care not to drip on the newly formed sheet.



13. To continue making sheets, place another felt directly on top of the sheet you just made. Make another sheet and then couch it onto the second felt, lining it up with the sheet underneath. You can create a guide for lining up your sheets of paper by using two pieces of tape to mark where to set the mould each time. Continue making sheets to form a post of paper.



14. As you make sheets, you are removing pulp from the vat. After every three to four sheets, you should add more pulp to replenish the vat in order to maintain consistency in the thickness of your sheets. The amount of pulp you add will depend on the size of the vat and the thickness of your sheets of paper. When adding pulp, remember to stir the vat thoroughly to mix in the new fiber.

Troubleshooting

Here are a few useful tips for avoiding or dealing with common mistakes:

- **Paper won't couch.** Check to see if the mould is upside down. If it is, the sheet will be impossible to couch, since it will be below the edge of the screen, surrounded by the frame of the mould. When you place the deckle on top of the mould, the screen side of the mould must be up and facing the deckle.

- **Sheet does not release from mould when couched.** Start with a wetter felt, or try gently pouring water on the back of the screen while couching. Use significant pressure at the edge that you are lifting and a little snap up to release the sheet.
- **Air bubbles created when couching.** After couching a sheet of paper, you may see an air bubble or two. This can happen if the felt is not damp enough, if it's not evenly dampened, or if the pressure on the back of the mould is not even when couching. If the bubbles are smaller than 1 inch (2.5 cm) in diameter, just leave them, and they will flatten out with pressing without damaging the paper. If they are larger than this, you can pop them with a needle or pin to let the air out.
- **Drip marks.** Be careful not to drip water onto the fresh sheets of paper when you remove the deckle from the mould. These water drops, known as "papermakers tears," will be noticeable in the sheet of paper after it dries. To avoid this, keep the deckle parallel to the mould while you gently whisk it over the surface of the sheet.
- **Lumpy sheets.** Make sure the pulp is thoroughly mixed in the vat before you pull a sheet. Remember to shake as you lift the sheet out of the vat — back to front and side to side. This evens out the sheet.
- **Pulp drains too fast — no time to shake.** Use formation aid (see here), or beat the pulp longer.
- **Kissing off.** If you aren't satisfied with the sheet of paper that comes out of the vat, don't just dunk your entire mould and deckle back into the vat. Remove the deckle, flip the

mould over, and smack the mould on the surface of the water. The sheet will fall into the water and your mould will be clean. This is called kissing off. Be sure to stir the vat again to break up this sheet before you pull another one.

Japanese Papermaking

The essential difference between Japanese and Western sheet formation is that while Western papermaking calls for just one dip, in the Japanese method, you dip the mould into the vat repeatedly, building up layers of fiber. The multiple laminations create more surfaces for fibers to bond, which makes these papers very strong. Japanese-style sheet formation is well-suited for working with long bast fibers and helps alleviate some of the knotting, tangling, and couching problems you may encounter when working with long fibers in the Western method.

Traditionally, Japanese papermaking is done using a *sugeta,* which is similar to the mould and deckle but has a few different features. The *su* is a flexible bamboo mould that is sandwiched between a hinged frame called a *keta*. The *keta* has a deeper deckle, which allows you to scoop up more pulp on each dip, move it around on the screen surface, and then toss the excess pulp (and any knots or clumps) back into the vat.

If you do not wish to invest in a *sugeta* (available from papermaking suppliers), you can simply adapt your Western mould and deckle to allow you to make paper using the

Japanese method. (See the instructions for making an adapted *su*.)

Formation Aid

Another variation in the Japanese technique is that a mucilaginous substance, called formation aid, is added to the vat. The traditional Japanese formation aid is *neri,* which is extracted from the roots of the Japanese *tororo* plant *(Abelmoscshus manihot)* by pounding the roots and soaking them in water. In a few hours the water becomes a thick, gooey slime called *tororo-aoi.* Adding the strained extract to the vat slows down drainage and leaves more time for dispersing fibers during sheet forming. It also prevents the fiber from clumping.

Making Your Own Natural Formation Aid

An alternative to *tororo-aoi* that is available in the United States is the fruit of the okra plant. Idaho papermaker Tom Bennick uses frozen okra from the supermarket. To make a solution, he stuffs ½ pound (230 g) of okra fruit into a piece of pantyhose, which he then soaks in a gallon of water overnight. This allows the viscous substance to be extracted; then he removes the okra and is left with enough formation aid to use with 1 pound (500 g) of fiber (dry weight). Keep this in the refrigerator and use it as

soon as you can — it does not last very long. Hibiscus and hollyhock roots can be used, too.

A synthetic formation agent is available from papermaking suppliers in powder form (see the mixing instructions in the box). As with any formation aid, strain it through a fine-mesh bag to prevent any clumps or powder bits from getting into your vat.

➤ A pillowcase can be used as a good substitute strainer for formation aid.

ABOVE: *Formation aid should be strained before it is added to the vat.*

The amount of formation aid required varies depending on the type of fiber and how it was prepared, the thickness of the sheet, and the quality of the paper you are making. More formation aid means your sheet will drain slower, which is useful when you're making thinner papers because it allows time for even distribution of fibers. If you use too much formation aid, it will not be possible to form a sheet. If you use less formation aid, the sheet will drain faster, which is okay if you are making thicker sheets because the sheet itself will slow drainage as pulp collects on the surface of the mould. However, since less formation aid means faster drainage, there is less time to cast off knots and lumps. Over time, you will develop a feel for how much formation aid you need to use. You should replenish the formation aid in the vat every time you add pulp.

Mixing Synthetic Formation Aid

Sprinkle 1 tablespoon (15 ml) of powdered formation aid into ½ gallon (2 l) of water and refrigerate, overnight. You can also sprinkle the powder into a blender filled with water, blend the mixture, and then dilute it as necessary. The formation aid is then added to the vat and mixed thoroughly with the pulp.

Step-by-Step Japanese Sheet Formation

Many papermakers have adapted techniques from the Japanese tradition because they work well with many plant fibers. These instructions are for making a sheet of paper using a *sugeta* or an adapted Western mould (see here), prepared formation aid, and the Japanese sheet-forming technique called *nagashi-zuki.* For complete information on traditional and modern Japanese papermaking, refer to *Japanese Papermaking* by Timothy Barrett.

Filling the Vat

1. Fill a utility sink half full of water and add 1 gallon (4 l) of hydrated pulp. Mix the pulp and water well for 2 to 3 minutes. Add 2 cups (500 ml) of concentrated formation aid and continue stirring vigorously. This will break up clumps of fiber. The slurry should feel viscous but not slimy.

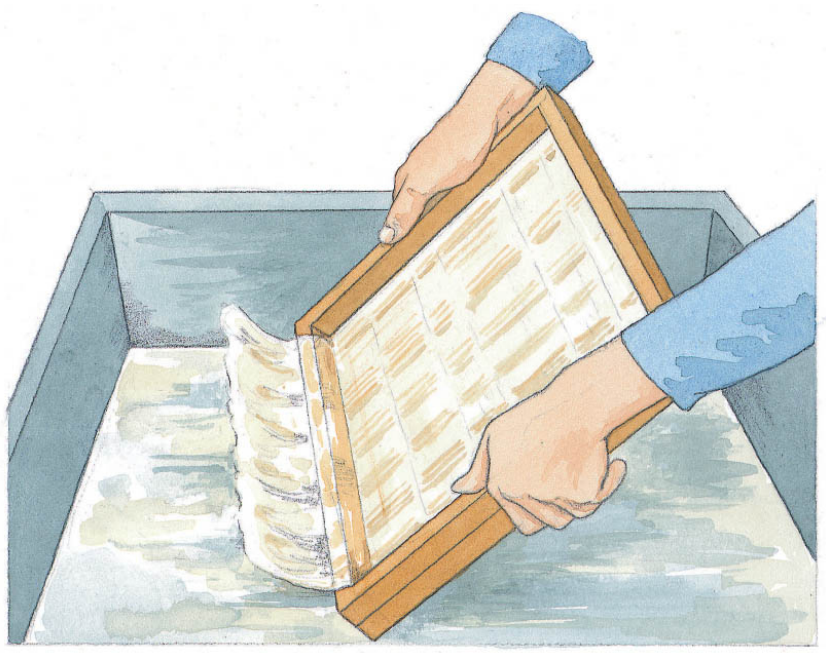
Making a Sheet

2. Place the flexible su in the keta or on top of the wire mesh mould and secure it in place by sandwiching it between the mould and deckle.

3. The first dip is quick, and is referred to as the “first skin” on the sheet of paper. To start, dip your sugeta into the vat as if you were forming a Western sheet, but when you pull it out of the water, tilt it away from you and toss off the excess water. You should see a thin film of fiber on

your screen. This first layer slows drainage of subsequent dips.

➤ While making your sheets of paper, pay attention to the drainage and add more formation aid if necessary. If the sheet does not stay adhered to the mould surface while you are dipping, it may mean you need more formation aid.



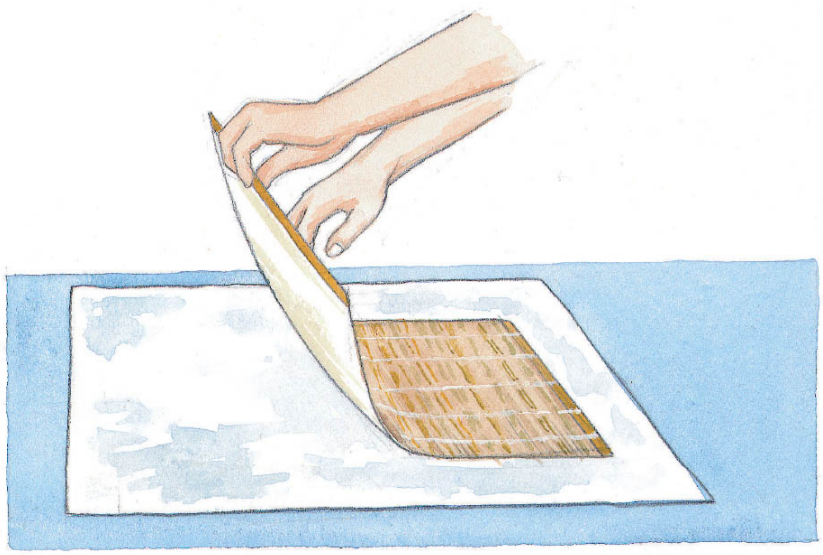
4. Dip a second time and hold the pulp in the deckle while rocking it back and forth to form the second layer. After a few rocks back and forth, toss the water off the back edge again.

5. Dip again and shake left to right, then toss off. Alternating the shakes from back and forth to left and right will form a stronger sheet with a less noticeable

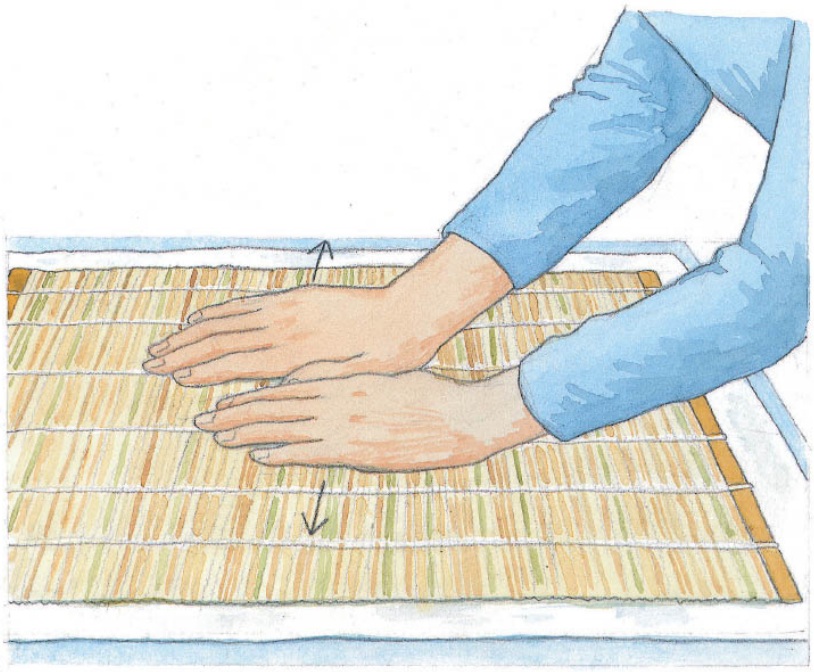
grain direction. Continue dipping and sloshing several times until your paper is the desired thickness.

Couching

6. Remove the deckle, lift up the flexible screen at one edge, and roll it down onto a wet pellon.



7. Brush the back of the su from the center out with even strokes, using the flat of both hands, to ensure that the sheet of paper sticks to the pellon. Apply pressure along the edge of the screen to make sure the paper adheres, then peel the screen away from the sheet of paper.



➤ If you have difficulty peeling the screen away from the sheet, peel it back slightly and gently brush the free edge of the sheet onto the pellon. After that edge is stuck to the pellon, you should be able to slowly peel away the rest of the screen.

8. Separate your sheets with felts or pellons to build up your post.

Deckle Box or Nepalese Papermaking

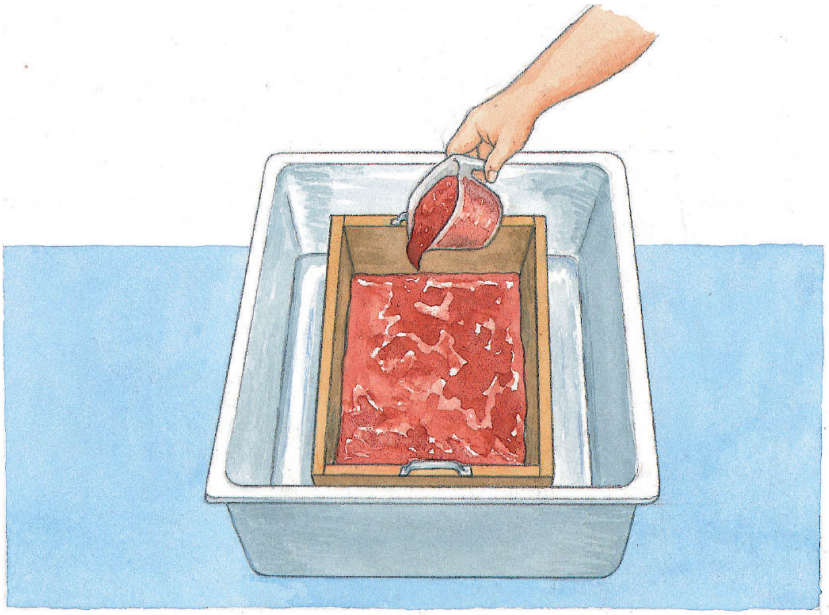
If you do not have enough pulp to fill your vat (with some plants, you may find that cooking leaves you with very little

pulp), you can make sheets of paper using a deckle box — a mould with a very deep deckle that simulates a vat.

This is a handy technique for making very thick sheets of paper, and you can also pour more than one pulp into the deckle box to create a multifibered sheet.

1. Place the deckle box in a vat and fill the vat with water that comes up approximately 2 inches (5 cm) higher than the surface of the mould. The water will fill the deckle box as well.

2. Pour a sheet's worth of pulp into the deckle box. You can distribute the pulp over the screen surface as you pour it into the deckle box, or you can stick your hand into the box after you have added the pulp and move it around (similar to stirring pulp in the vat).



3. Lift the box up and shake as you would to form a Western sheet. Remove the deckle and couch as usual.

Storing Pulp

When you are finished making paper, some pulp will be left in the vat. If you plan to continue making paper soon, you can leave the pulp in the vat in a cool area for a few days. You might want to cover the vat with plastic or a board to prevent dirt or bugs from falling in and contaminating it.

Pulp that has been sitting in a vat should be thoroughly rinsed in clean water before it's used or refrigerated. Pulp can sit in a vat for a couple of days before it starts to smell, which indicates that fermentation has begun. Some papermakers "refresh" their pulp by adding a few drops of bleach diluted in water to pulp that has started to sour, followed by a thorough rinse.

If you want to store the pulp, you must first drain if from the vat. If your vat has a drain plug in it, just slip a bucket with a strainer in it underneath the drain. Watch that the strainer doesn't overflow, because the pulp will slow the drainage. If you don't have a drain, scoop the pulp into a kitchen strainer that is resting over a bucket or in a sink. Line your strainer with cheesecloth, pellon, or a fine mesh to catch the smallest bits of pulp.

Depending on how soon you will make paper again, you can either refrigerate or dry out the pulp for future use. I store my leftover pulp in zipper-locking plastic bags, labeling them with

the date and name of the fiber. Refrigerated pulp will last a few months before it begins to rot. You can even freeze pulp. Dried pulp, which keeps indefinitely, usually returns to its original state when rehydrated, but it will also need to be rebeaten. A good way to dry pulp is to break it into small clumps and lay it on a screen so that air can get to it from all sides. When it's dry, you can pack, label, and store it. When you decide to make paper again, rehydrate the pulp and beat it again.

Keep in mind that anytime you store pulp, it might change in character (frozen or dried pulp will not return to its original state). If you want a consistent look to your sheets, make them all at one time.

Pressing Techniques

Pressing removes water from the sheets of paper and compacts the fibers tightly together as they bond. After pressing, the sheets will still be damp and will need to be dried. All kinds of systems have been rigged for pressing, ranging from piling heavy books or rocks onto the post to using a garbage bucket filled with water (the more water, the more weight) and using a hydraulic jack to create pressure. The first presses in Europe were wooden screw presses, which took the strength of many men to tighten. Similar presses were used in the Far East. In some countries, papermakers developed systems of drying sheets of paper directly on the moulds, eliminating the need for a press. Other systems involved drying sheets on boards or walls.

Some of the techniques described here are centuries old, while others are recent innovations, developed by contemporary papermakers who have designed systems to meet their needs. Several of the papermaking suppliers listed in the Resource Guide sell presses.

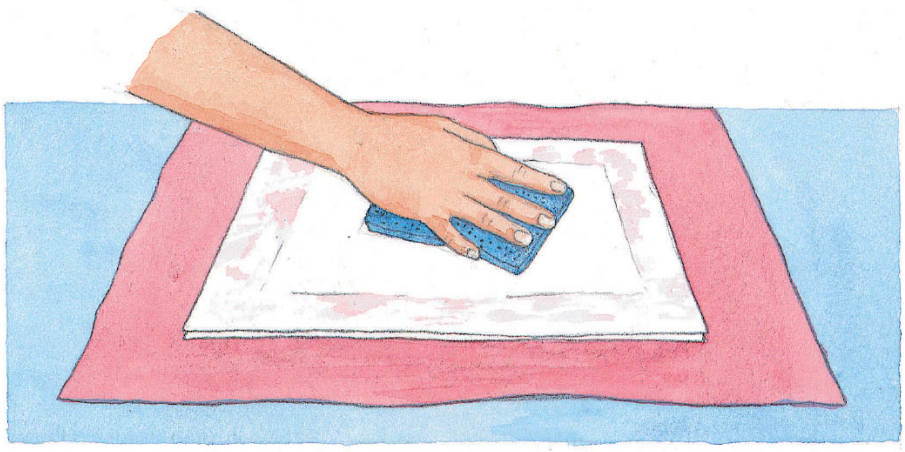
Pressing Multiple Sheets

If you are pressing different types or sizes of papers together, you might want to put a barrier of wood, metal, or firm plastic between the layers, so that they are in effect pressed separately. For example, if you are pressing plain white sheets together with pigmented sheets of paper, they should be separated by a barrier so that the color does not bleed into the white sheets. In this particular case, the white sheets should be on top of the barrier to ensure that no color drips down onto them.

Sponge Press

A low-tech method of pressing is using a sponge — use a clean sponge, so that you do not contaminate your paper. To do so, press your sheets individually as you make them and then hang them on a line or place them in a rack (see Drying Techniques). I recommend that you couch onto pellon when you press with a sponge, because it is less absorbent and will require less sponging.

Take one sheet of paper with its pellon and place it onto a dry felt or newspaper (something that will absorb some of the water). Then place a dry pellon on top of the sheet to protect the sheet's surface, and gently but firmly sponge water out of the sheet. Repeatedly wring out your sponge and continue pressing the rest of the sheet. Be careful not to damage the sheet by pressing too hard; still, remove as much water from the sheet as you can. It is also important to press the sheet evenly, so that all of it will dry at the same rate. Your sheet is now ready to be dried. Continue pressing the remaining sheets.

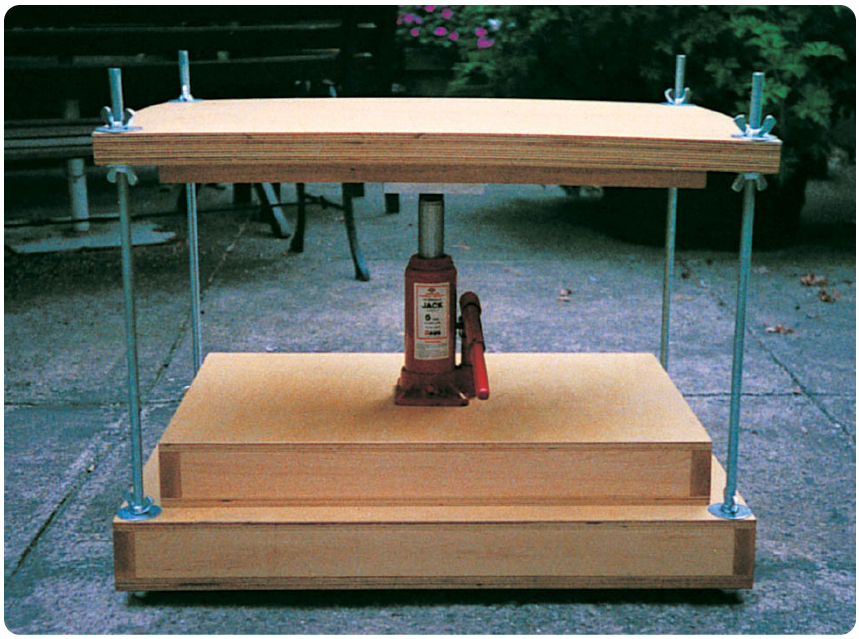


➤ Instead of a sponge, you can use a rolling pin or an ink brayer to remove moisture from your sheets. Since these tools do not suck up moisture like the sponge, you will need to place your sheet in between something absorbent, like newspaper, towels, or felts, so that the moisture is transferred to the absorbent material as it is rolled out. Press gently at first — if you press too hard, you will distort your sheet.

Found or Adapted Presses

You might adapt or use a press that was designed for another use, such as a flower press, cider press, or book press. Just make sure you can fit a stack of paper into it (many printing presses press only one sheet at a time), and watch out for presses with metal parts that will rust. The staff of the Dieu Donné Papermill, a hand papermill in New York City, for instance, needed an electrically powered hydraulic machine that could press up to 100 sheets of paper. They found the perfect machine, a farm implement originally designed to bale hay. It can press over 100 sheets at a time.

Many papermakers have built presses that uses a car jack for pressure. I have seen many variations of this press at facilities around the country, each constructed to meet the pressing needs of a particular studio. Arnold Grummer even built a portable press using a jack for use in the classroom. Instructions for building his press can be found in his book Paper by Kids (see Reading List).



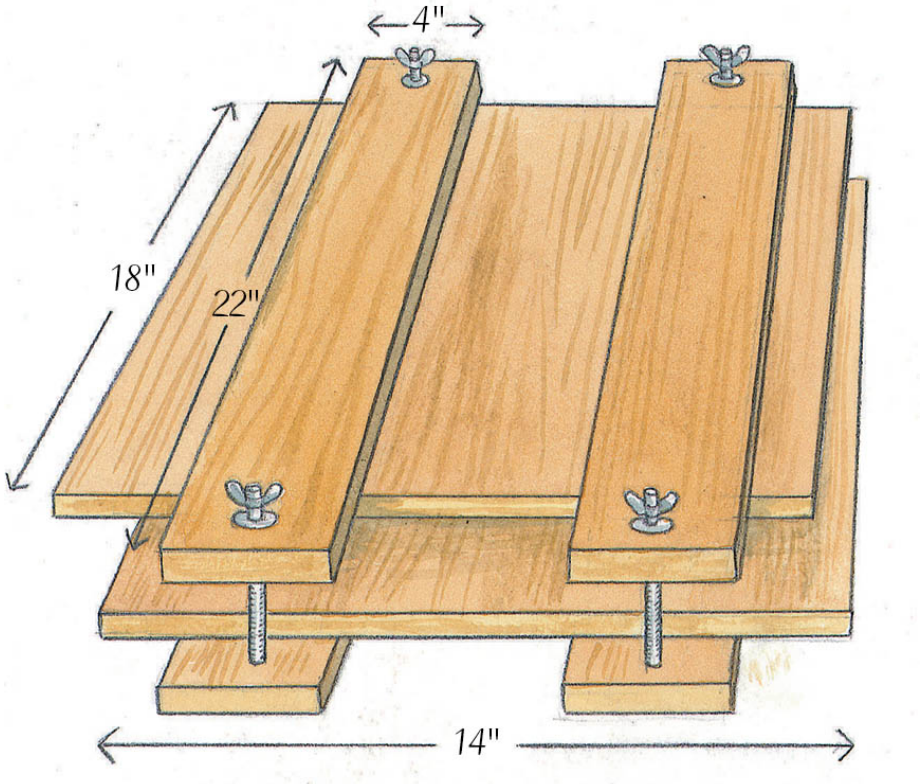
Helen Hiebert

ABOVE: *This is just one of the many variations of the adapted car-jack press.*

Making Your Own Simple Press

A step up from the sponge press is a simple plywood press. Your post of paper can be placed between two polyurethaned boards, and C-clamps can be attached to each of the four corners and tightened. Pressing will release a fair amount of water, so you might want to work over a tub or tray, or work outside.

A similar plywood press is easy to build. The following instructions are for a press that will accommodate sheets of paper up to 11 by 14 inches (27.5 by 35 cm) in size.



MATERIALS AND EQUIPMENT

2 pieces of ¾" plywood cut to 14" x 18" (35 x 45 cm)

4 pieces of 1" x 4" wood cut to 22" (55 cm) lengths

Polyurethane (I use water based to reduce fumes)

Brush

Drill with 3/8" bit

4 1/4"-diameter and 6"-long carriage bolts (make sure they are threaded to at least 1/2" [1.25 cm] from the head)

8 washers that will fit the carriage bolts

➤ Be sure that the plywood is smooth — check that it has no indentations, which could be pressed into your sheets of paper.

TO MAKE

1. Apply at least two coats of polyurethane to each wood component.

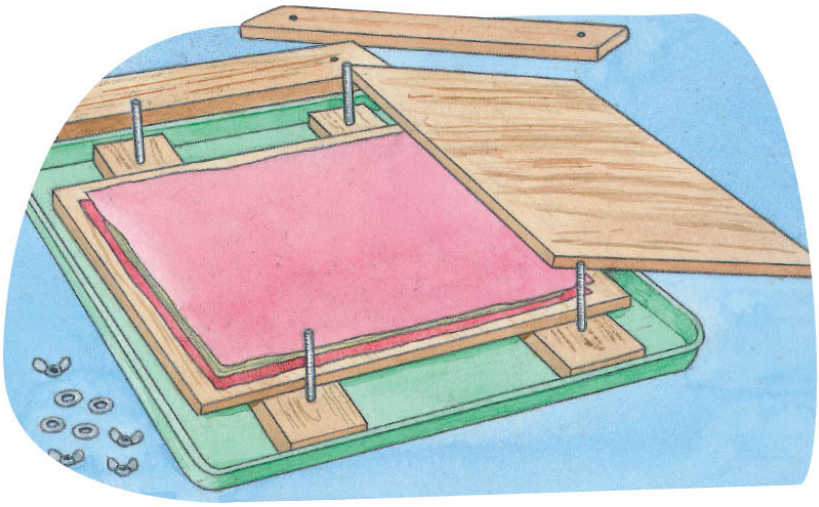
2. Drill one hole at each end of the two 4" x 22" pieces of plywood, centered in the 4-inch (10 cm) direction and 1 inch (2.5 cm) from the ends. Make sure that the carriage bolts can slide through the holes. Slip the carriage bolts through the holes in the long pieces of plywood to assemble the pressing mechanisms, placing a washer on each side of the plywood.

TO USE

3. Use one of the pressing boards as a couching base and form your post directly on top of it. When you're ready to press, make sure you have a pellon or felt covering the top sheet, and put the other pressing board on top of this. Open the pressing mechanisms and slide one onto each end of your press.

4. Gradually tighten the bolts, moving from one to the next as you go to maintain even pressure. Tighten them as much as you can.

5. Release the bolts and slide out your pressed post of paper.



Vacuum Table Press

During the 1970s, papermaking made a resurgence as an art medium in America. Artists began "pushing the medium," developing innovative ways to work with paper and pulp. One

such innovation is the vacuum table: a tabletop with small holes in its surface, a holding tank underneath, and a connection for a strong wet-dry vacuum. Plastic is draped over sheets of paper lying on the table surface, and when the vacuum is attached and turned on, it sucks the plastic down onto the sheet, drawing water out. This system can press very large sheets of paper — which would be difficult, if not impossible, to fit into a hydraulic press (not to mention lifting them into it) — as well as high- and low-relief sheets and sculptures. Instructions for building one such vacuum system can be found in Volume Six, Number One of *Hand Papermaking* magazine (see Reading List). Some papermaking suppliers also carry them.

Using a Hydraulic Press

Many papermakers use hydraulic jacks to supply the force in their press. When you're using any type of hydraulic press (press with a hydraulic jack), load your post of paper into the open press, then bring the press to full pressure. In some cases — for example, if your paper is very thick — you might need to press the paper gradually. This is very important, because if you press too quickly, the water will explode out and damage the wet paper. When the press has been brought to full pressure, leave it for 15 minutes to an hour, depending on your press and the particular post of paper. You want to make sure that water is removed from the entire sheet. With most presses, the pressure hits the center of the sheet first, and allowing it to sit gives the water time to move from the center

and seep out of the edges. Release the tension and remove the post when you are done. If the sheets still seem very wet, you can press them again. The sheets are now damp and ready for drying.

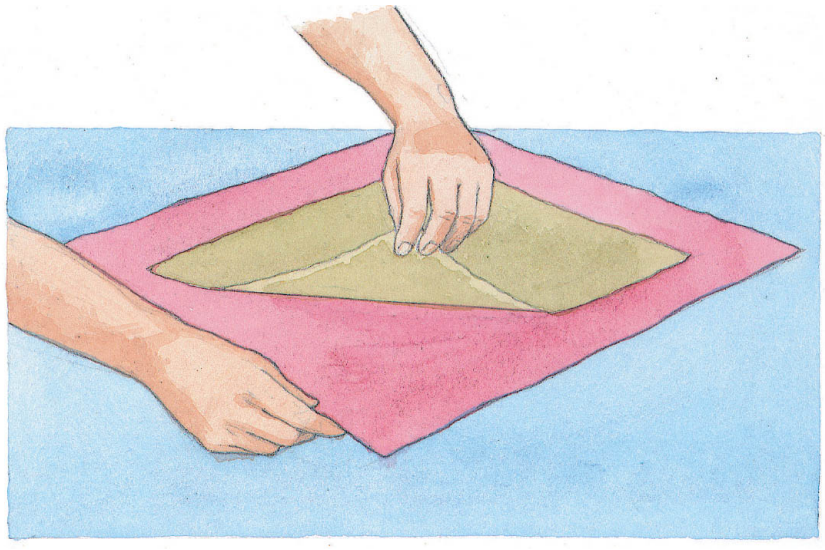
Although it is not necessary, fitting a hydraulic press with a gauge that measures the pressure can be handy, enabling you to record the amount of pressure you use for different techniques. In general, you can press papers to full pressure, but if you are board or loft drying (see here) you will need to adjust the amount of pressure you apply.

Handling Damp Paper

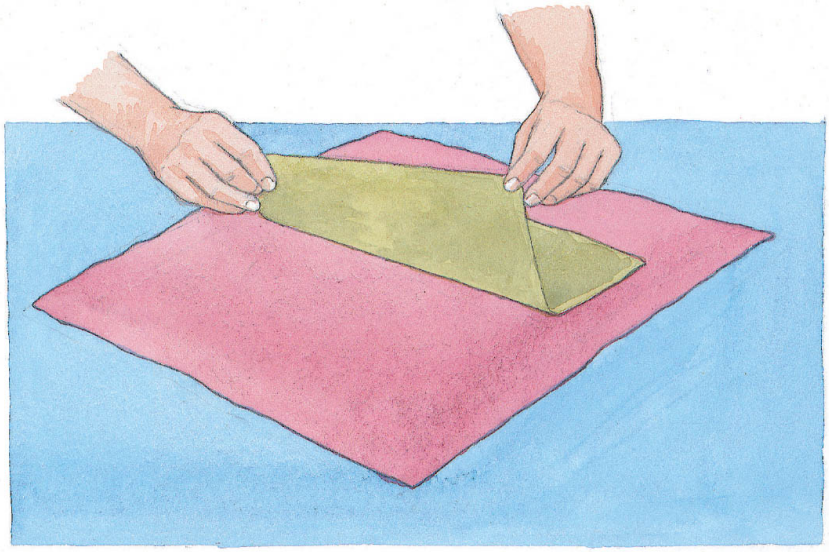
After pressing, your paper is much drier than when you first couched it, but it is still damp and very fragile and needs to be handled with care.

Thin Sheets

1. When you're working with small or thin sheets, remove a sheet from a felt by starting at one corner on a short side of the sheet. Taking care not to damage the corner, gently get your fingers underneath it and start peeling the sheet off the felt. I like to put at least three fingers behind the sheet and my thumb in front, so that I have a good grip.

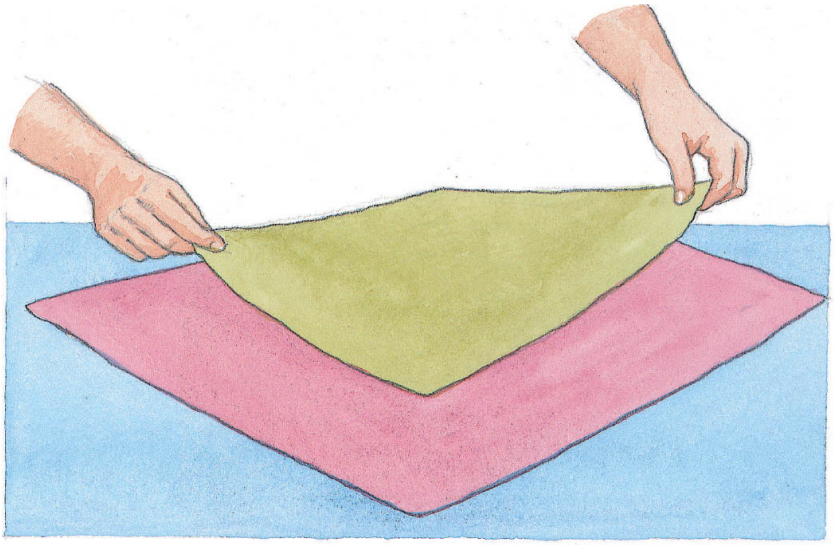


2. Hold the sheet taut but do not stretch it. Lift toward the other corner of the short side of the sheet and, when you reach it, take hold of it with your other hand.



3. Continue to pull the sheet off the felt. To lay the sheet onto a surface, gently place the bottom edge on the surface and roll the sheet down onto it, trying to avoid

any creasing or bubbling. You can gently lift and reposition the sheet if necessary.



Thick Sheets

For thicker, larger sheets, the traditional Western method of lifting sheets from a post is to grab two diagonal corners and gently lift.

Felt Maintenance

It is very important to keep your felts clean: Any residue left on them could end up in your next batch of paper. It is equally important to thoroughly dry your felts between uses so that they do not mold or mildew; it is extremely difficult to remove mold or mildew once it has started to grow.

You can wash your felts in a washing machine, but use very little detergent and dilute it before putting it into the machine. Because machine washing tends to wear felts down more quickly, you should check them periodically for wear and tear. Many papermakers brush their felts with scrub brushes to get rid of pulp and paper fragments. This can eliminate the need to wash, but it, too, increases wear and tear. The gentlest cleaning method is soaking felts in water and/or spraying them with a hose. To dry your felts, simply hang them between uses. A clothesline works fine, or you can build a simple, space-efficient rack system with a couple of strips of wood, some screws, and clothespins. This rack can double for loft drying paper, too (see here).

Drying Techniques

Some things to consider when choosing a drying system are climate, space, and the look of your finished sheets. I recommend starting simply. There is no need to invest in an elaborate system; I have seen beautiful, high-quality papers that were made using basic equipment.

The more humid the climate is, the longer it will take to dry papers. Where you will dry your papers is another consideration. You can hang them on a clothesline, dry them in spurs (four to five sheets stacked together), lay them out to dry on a table or a rack, brush them onto boards or walls, or set up a drying system (see here). The method of drying you choose will affect the texture of your papers as well. Experiment with

different techniques to see which you like. Try drying one type of paper in different ways, and compare your results.

Mould and Air Drying

In some countries, papers are not pressed at all: They're dried directly on the moulds on which they were formed. The sheets stick to the screen surface and are held taut as they dry. When dry, the sheets can be peeled off. This system is typically used in dry climates; sun dries the sheets rapidly, and the moulds can be reused. Although the system requires the use of many moulds, it does eliminate your need for a press and a drying setup.

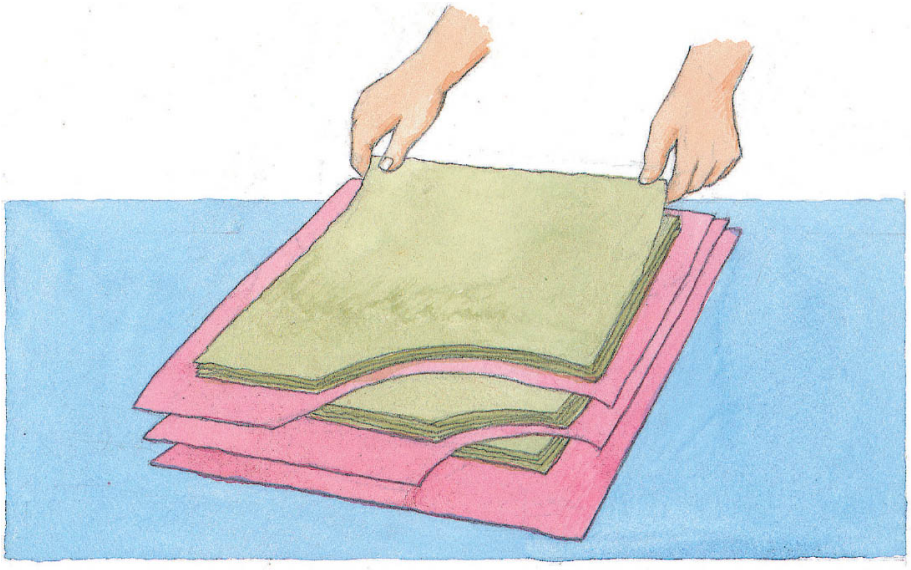
Another simple method is air drying — just let your sheets of paper dry on the surface upon which you couched them. I recommend couching onto pellon if you are going to air dry, because it dries quickly. Spread the pellons out on screens or on a rack so that air circulates around them, or hang them on a clothesline to dry. You can also pin pellon to a wall or board to hold it taut as it dries. When the sheets are dry, just peel them off it. The sheets might cockle (curl) slightly — you can put them under clean, heavy books or boards to flatten. If they are still cockled, gently mist them with water to help them relax, and put them under weight between blotters or newsprint.

Air Drying on Silkscreen

Another process I've seen that does not require a press or a drying setup was developed by Nance O'Banion. She was doing a lot of silkscreen printing and wanted to figure out a way to adapt her equipment for papermaking, as well as make good paper with less equipment (which she calls "schmo-tech"). She had a series of 4-by-8-foot (1.2 x 2.4 m) wooden frames with silkscreen stretched across them. She couched freshly formed sheets of paper directly onto a screen that could be propped against a wall. Many sheets could be couched onto one of these screens, and they were either left in the sun to dry, or the water was sucked out of them from the back by running a wet vac over the screen.

Loft Drying

To loft dry your sheets, you must first press them. After pressing, separate them from their felts and pile them in stacks (or spurs) of four to six sheets each (depending on their thickness), to prevent them from cockling very much as they dry. Pile the sheets one on top of the other, lining them up precisely. Rotate some sheets so that the stack isn't piled exactly as it was for the first pressing. This will help even out any inequalities in the sheets. Put a felt between each spur and form a post of spurs.

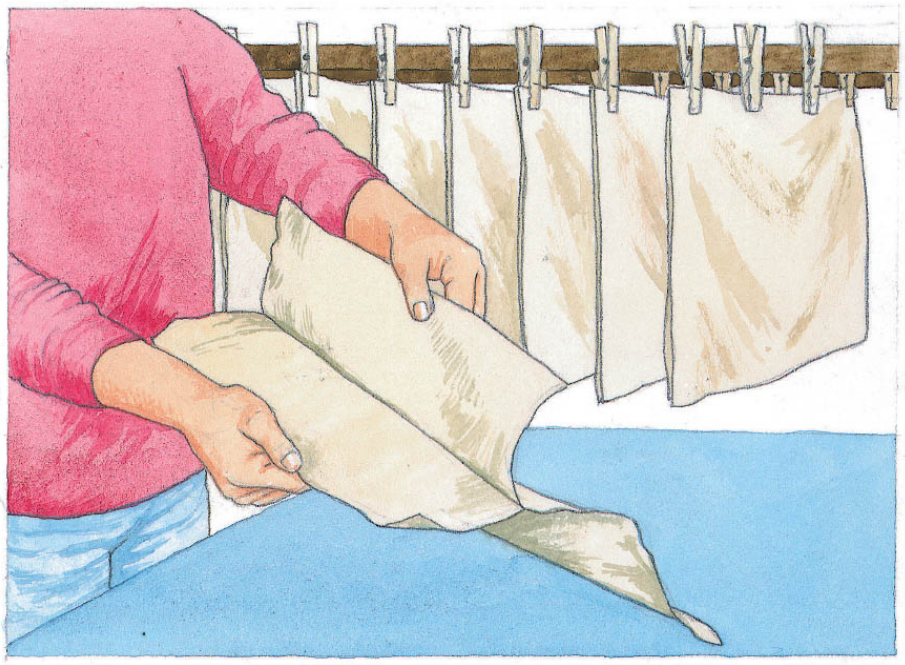


ABOVE: *Cutaway view of a post of spurs*

Put this post in the press again and press a second time, this time just until you see drops of water forming at the edges of the felts. More pressure could inhibit separating the sheets in the spurs when they are dry. After pressing, the sheets in each spur should be securely stuck together. You can hang the spurs on a clothesline with clothespins, or you can lay them flat on a rack or screens. (Make sure they get air from all sides so they dry evenly.) Alternately, you can drape the spurs over plastic tubing or thick ropes. Pretest the material you use to make sure it won't stain your paper.

If you can control the air circulation, try to direct it to come into contact with the breadth of the sheets, not the edges, for the least amount of cockling. When they're dry, separate each spur by starting at one corner and peeling the sheets apart in one fluid motion. Separate the spurs in halves: If you have a spur of four, for instance, first divide it into pairs, then

separate the pairs into single sheets. Your sheets will probably cockle to some degree, but they can be flattened with another pressing. Make a stack of individual sheets, rotating them again, and press them again to flatten. If the sheets cockle a lot, you may need to gently moisten them with a spray mister to relax them before you press.

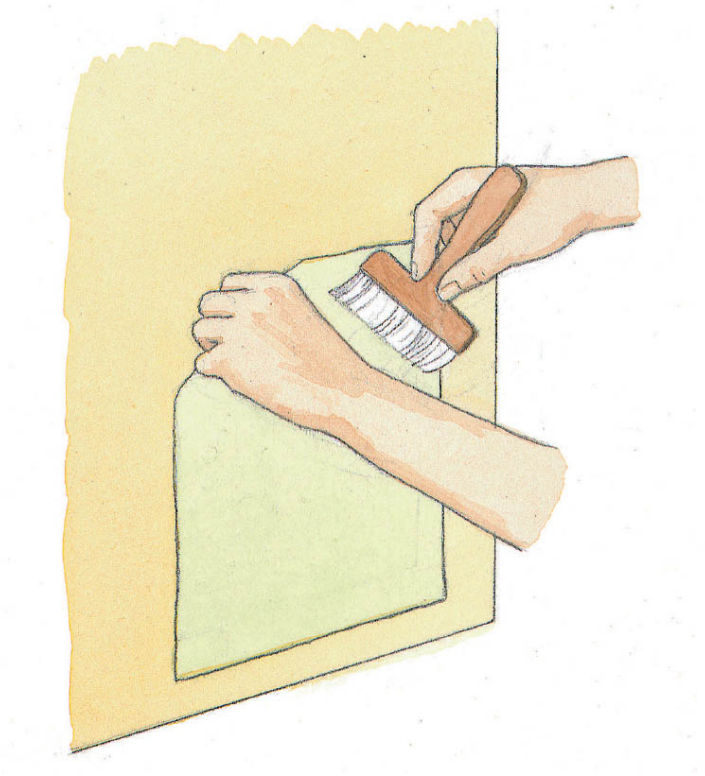


ABOVE: *Spurs (and clean, damp felts) can be hung to dry on a clothesline. To separate a dried spur, peel sheets away from each other in one fluid motion.*

Board or Wall Drying

In China, Japan, and other Eastern countries, sheets of paper are often brushed onto boards or walls for drying. The sheets stick to the boards and are peeled off when dry. The paper takes

on the finish of the board or wall, showing the grain or texture on the side of the sheet that was stuck to the surface. You can use almost any smooth surface for drying papers, such as wood, metal, glass, plexiglass, or formica. You can even brush your sheets onto plaster walls, as is common in India, where the walls are heated by the sun and the sheets dry quickly.



ABOVE: *When board or wall drying, brush each sheet onto the surface with firm, even strokes.*

To board or wall dry, first gently press your sheets — they should not be quite fully pressed (i.e., they should retain some moisture) or they won't stick to the boards. Lift one sheet from

its felt and lay it on the drying surface. Use a rubber brayer or wide paintbrush to affix the sheet to the surface.

If you're brushing onto a vertical surface, there is a technique you can use to adhere it while keeping it from falling to the ground. Start by brushing diagonally from the center toward the upper right corner of the sheet. While holding the upper left corner with your fingers, brush from the upper right corner to the bottom left corner. Next, brush from the center to the upper left corner; then continue brushing from the center out, to adhere the rest of the sheet. Make sure that you cover the entire surface of the sheet, brushing with firm, even strokes. If the sheets were pressed correctly, you should be able to brush firmly without damaging their surface. The edges must be well adhered, because they will dry the fastest and could pop off the drying surface. If the edges curl before the sheets are dry, they will shrink more than the rest of the sheet and be difficult to flatten.

Some fibers shrink a lot when drying, and will pop off boards before they are dry. You can try applying methyl cellulose (see here) to the edges of the sheets as you apply them to the boards to help them stay adhered until dry. If you are drying your sheets outside, you might try starting them in the shade and then moving them into the sun after they are somewhat dry. This allows them to dry slowly and might prevent them from popping off.

When they're dry, peel the sheets of paper off the boards. Start at one corner and peel in one fluid motion. If you have a problem releasing the corner, try using a razor blade to lift it, but be careful not to damage the drying surface.

Make Your Own Drying Box

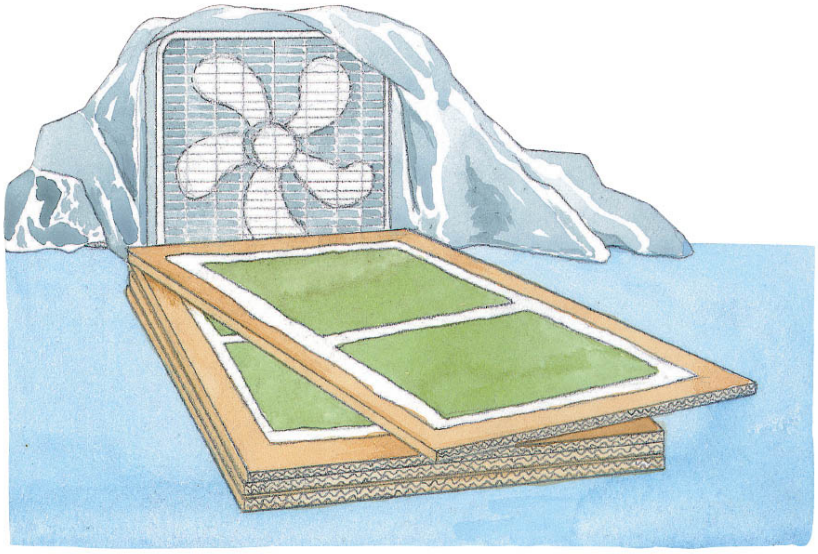
MATERIALS AND EQUIPMENT

- Cotton printing blotters
- Biwall or triwall cardboard (2 or 3 layers of cardboard laminated together)
- Plastic sheeting
- Box fan

➤ Make sure that the channels of the cardboard run in the direction of the length of the system (not the width of the fan). You will need one piece of biwall or triwall and four blotters per layer.

INSTRUCTIONS

1. To load your drying box, set your fan on the edge of a table or flat surface. Set a piece of laminated cardboard flat in front of the fan and place two blotters on top of it (the blotters should be no larger than the cardboard — two layers protect the cardboard from getting too wet). Next, place as many damp sheets of pressed paper side by side on top of the blotter as you can fit. Put another two blotters on top and then another cardboard.



2. Repeat until you reach the top of the fan. Make sure you stack your system evenly, and do not stack above the top of the fan.

3. Cover the sides of the system with a piece of plastic sheeting, leaving the front and back ends open. Tape the plastic to the sides of the fan to help direct the flow of air from the fan through the stack and maximize the efficiency of the system.

4. Place a sheet of cardboard or a board against the two sides to keep them flat against the edges of the stack. You will need to secure these from blowing over when the fan is turned on by leaning a brick or other heavy object against them. Put weights, such as cinder blocks or buckets of paint, on top of the stack to keep the sheets flat as they dry. Turn the fan on high and check the sheets in 24 hours. When the sheets are dry, unload the system.

Surface Sizing

Surface sizing is one of many finishing techniques you can perform on sheets after they are dry. Sizing, available from most papermaking suppliers, coats the fibers and makes them less absorbent. Papers that have no sizing are called waterleaf and they are generally quite absorbent.

Surface sizing is applied to dry papers and gives them a sturdier finish than internal sizing. Some common materials used for sizing include corn, rice, and wheat starches and gelatin. Alum, a chemical often used as a mordant in dyeing, can be added to the gelatin for use with photographic and printing techniques that require remoistening the paper — it hardens the gelatin so that it does not dissolve. For additional information concerning alum and other types of sizing, please consult William Crawford's *Keepers of Light* (see Reading List).

➤ You can also size your papers internally by adding sizing to the pulp prior to sheet formation (see here).

Make Your Own Gelatin Sizing

This is a standard recipe for gelatin sizing using a 2 ½ solution (2 ½ percent gelatin based on amount of water). Gelatin sizing is used while it's still hot.

MATERIALS

1 ¾ oz. (50 g) gelatin (7 packets of Knox brand gelatin)

2 quarts (2 l) cold water

INSTRUCTIONS

1. In a nonreactive pot (stainless steel, enamel, or glass), dissolve the gelatin in the cold water. Allow it to sit for at least 10 minutes to absorb the water and thicken.

2. Heat the solution to just under a boil and keep it hot — if the gelatin cools it will start to thicken and application will be difficult.

3. There are two techniques for applying the gelatin to the paper:

    - **Method 1.** Work on a clean, nonporous surface. Wring out a sponge or wide brush in hot water and then dip it

into the gelatin solution. Brush or wipe the gelatin onto the surface of the sheet in even strokes in one direction. If you wish to coat both sides of the sheet, turn it over and brush gelatin onto the other side of the sheet.

- **Method 2.** Pour the gelatin solution into a shallow tray or vat that is larger than your sheets of paper. Place a sheet of paper in the solution, then turn it over to coat the other side. Leave it in the solution for 1 minute, then lift it out and allow the excess solution to drip back into the tray (otherwise you will get a buildup of gelatin on the bottom edge). You can use a dowel to help you lift the sheet out of the solution.

4. After applying sizing with either method, stack the sheets one on top of the other and press them to remove any excess gelatin.

5. Hang your paper with clothespins on a line. Hang them loosely, with a slight bow, because they will shrink as they dry.

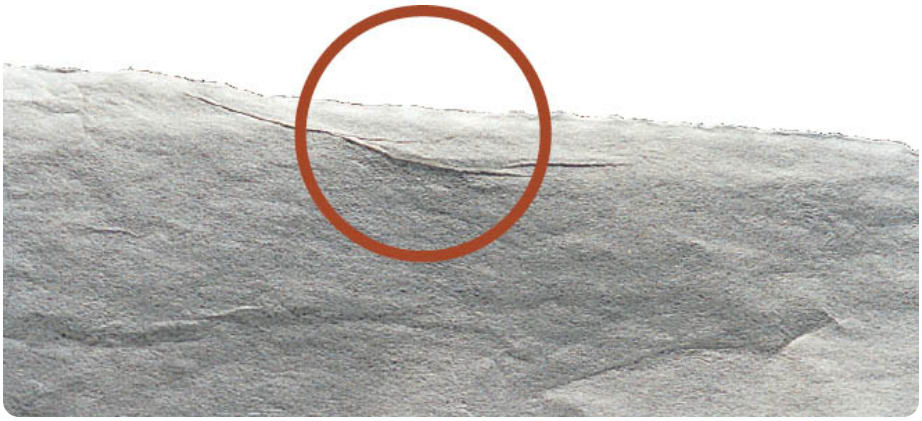
Evaluating Paper Quality

Now that your papers are dry, you can examine them for flaws. In production shops, sheets are "curated" before they go to the customer: They're separated into firsts (good sheets) and seconds (sheets with imperfections that do not go to the customer but get used for something else). To the right are representations of some imperfections, which will give you a sense of what could happen during the process.

Keep in mind that a mistake isn't always devastating. Papermaker Marilyn Sward once made some paper that accidentally got left out in the rain. She thought the resulting pockmarks made a beautiful paper and she decided to replicate it. When it didn't rain again for several days, she rigged a dripping system from her gutter to simulate rain and made more sheets. There are no guidelines as to what makes a perfect sheet of paper; it is up to you to set your own standards. The quality depends on the end use of your sheet — some flaws, like a water drop, might not be visible if the paper will be used for a print, but would be obvious if it's used for a lampshade.

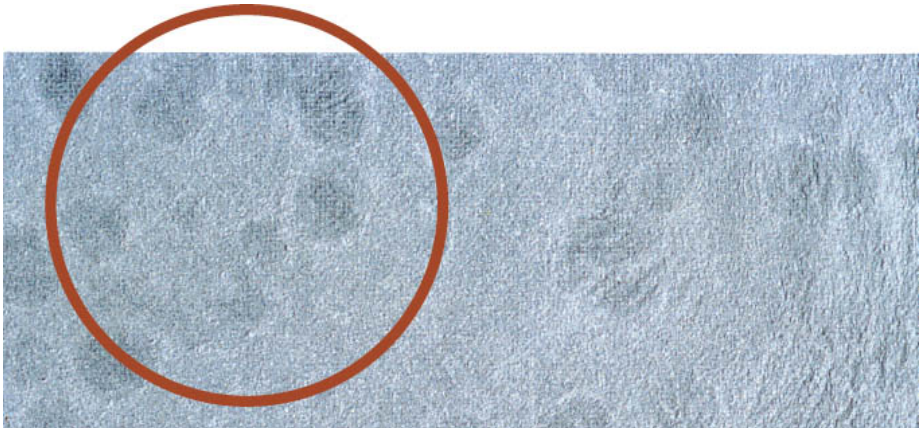
- **Crinkling or creasing:** Poor handling of the pressed sheets
- **Dinged corners:** Poor handling

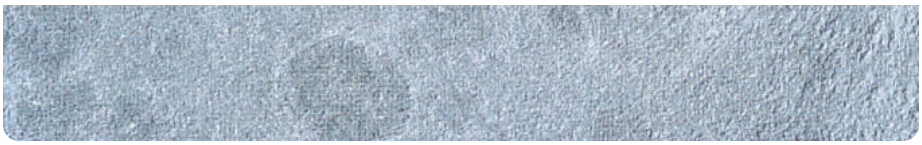
- **Water drops:** Improper deckle removal or other carelessness
- **Dirt:** The mould, felts, or blotters were not clean enough
- **Uneven sheet formation:** Did not shake enough, shook too hard, pulp was not properly prepared or was not rehydrated properly, or the sheet was not held level when draining
- **Stretch marks or air bubbles:** Improper couching



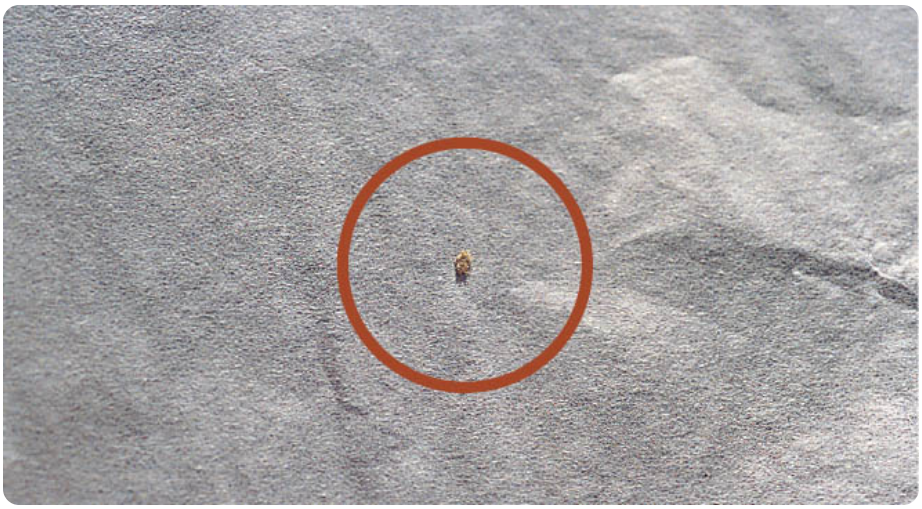
ABOVE: *Crinkling or creasing*

ABOVE: *Dinged corners*



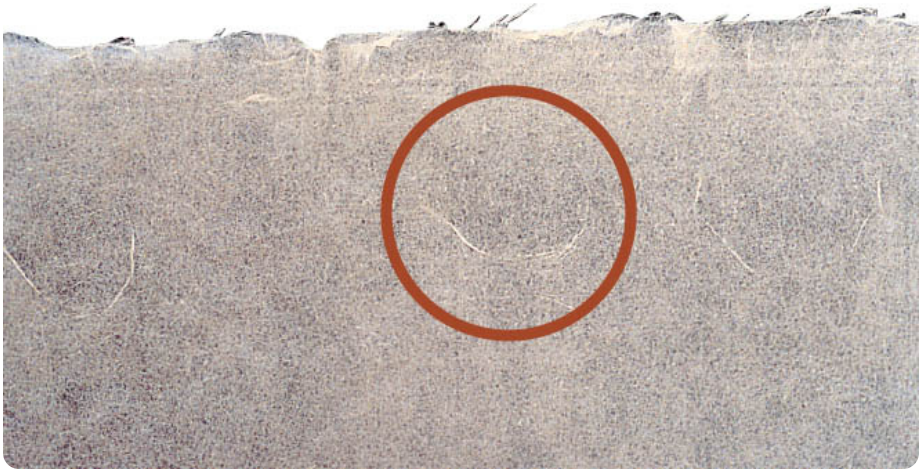


ABOVE: *Water drops*



ABOVE: *Dirt*

ABOVE: *Uneven sheet formation*



ABOVE: *Stretch marks or air bubbles*

Keeping a Detailed Record: Part III

Sheet Formation, Pressing, and Drying Record

Additives in the vat: None

Did you use formation aid?

Sheet-formation method: Western-style

Which method did you use — Western, Japanese, or deckle box?

Formation comments: Pulp drained quickly; might try using formation aid

Did you have any difficulty forming sheets?

Couching: Couched onto felts

Did you use a couching material such as felt or pellon?

Pressing: Hydraulic press

What type of press did you use?

Drying: Restraint dried

What type of drying system did you use?

Sizing or finishing: None

Did you gelatin size or burnish your sheets?

Sheet size: 11" x 14"

Quantity: Unknown

How many sheets did your fiber yield?

Shrinkage: None

How much, if any, did your sheets shrink?

Strength: Weak

Does the paper hold up to folding? How easily does it tear?

Absorbency: Low

If you draw on the paper with ink, does it bleed or cockle?

Appearance: A crisp paper with a light brown color and with visible fibers

What does your paper look like?

CHAPTER 5

Recipes, Techniques, and Projects

As in cooking, a papermaking recipe will not ensure precise results. I think it is useful to have some guidelines when you begin though, so I have included a variety of plant fiber recipes from many different papermakers. Please try them and adjust them to your needs. There is no one way to make a sheet of paper, just as there is no single correct way to make chicken soup. The amount of detail in each recipe varies somewhat, because some of the papermakers measure their ingredients precisely, while others use a little of this and a little of that. If you're interested in precision (and you should be if you want to make a high-quality paper), jot down your own recipe as you prepare your pulp and make your paper. The most important advice I can give is — have fun!

You'll also find techniques for making unique papers, as well as for making various objects with handmade paper. These techniques are suited to most garden plant fibers. Many other techniques are possible, of course; I hope that these few projects inspire you to develop your own and explore other techniques.

Paper Mulberry

Broussonetia papyrifera

Recipe developed by Mina Takahashi

ABOVE: *Bast fiber of the paper mulberry plant, dried and bundled*

ABOVE: *View of paper as held up to a light*

PLANT FAMILY: Moraceae

TYPE OF FIBER: Woody bast fiber

PLANT PART USED: Inner bark

AMOUNT OF FIBER: 1 1/2 pounds (680 g) dry fiber

ALKALI: 6 ounces (170 g) soda ash (25% of dry fiber weight)

VOLUME OF WATER: 12 quarts

HARVESTING: Harvest several branches that are 3/4 to 1 1/4 inches (2 to 3 cm) in diameter and 8 to 9 feet (2.4 to 2.7 m) in length. Remove small branches and leaves and cut the shoots into even lengths that fit into a large cooking vessel.

ADDITIONAL FIBER PREPARATION: Steam the branches for at least 30 minutes, until the bark shrinks back and is easy to peel away from the woody core. Strip the bark in equal widths of approximately ¾ inch (2 cm) — this will help the fiber cook evenly. Keep the peeled bark damp, and scrape off as much of the black outer bark as possible. If time allows, bundle the bark strips and hang them in the sun to help remove the green chlorophyll layer. You can also scrape off this layer, but you risk scraping away some good fiber.

PRECOOKING PREPARATION: Soak the fiber for 12 hours (if dried out), changing the water every few hours.

COOKING: Fill a nonreactive cooking pot with the water and add the damp fiber. Heat, and add the soda ash to the water prior to boiling. Cook for 4 hours, stirring the fiber every 30 minutes, until it pulls apart easily. Let the fiber sit in the cooking solution until it cools (at least 4 hours).

RINSING: Rinse the fiber twice by dunking it into buckets of clean water. Do not spray the fiber directly with a hose or you will lose the finer strands. Pick the bits of black bark off the strands of fiber in a clean basin of water (this picking process is called *chiritori* in Japan).

BEATING: Take a ball of pulp the size of a cantaloupe and squeeze out the excess water. Hand beat with mallets for 10 minutes, “dry” to loosen the strands of fiber, and then add ¼ cup (60 ml) of water five times, beating 3 minutes in between, until a pinch of

fiber dispersed in water in a jar and shaken is free of clumps (see here).

Formation aid: Add formation aid to the vat. Fill a utility sink half full of water, add 1 gallon (4 l) of hydrated pulp, and mix the pulp and water well for 2 to 3 minutes. Add 2 cups (500 ml) of concentrated formation aid and continue stirring vigorously. The slurry should feel viscous but not slimy.

SHEET FORMATION: Japanese-style *nagashi-zuki*.

➤ If the fibers do not layer on the screen, try rinsing the fiber again — too much hemicellulose may have been released during beating, making sheet formation difficult. Also, if subsequent dips into the vat disturb the layers of fiber, you may need to add more formation aid.

COUCHING/PRESSING: Traditionally, Japanese papers are couched one on top of the other, with just a piece of thread laid down on one edge to facilitate separation after pressing; an entire post is formed without felts.

- For a post with threads between the sheets, cover the post with a sheet of pellon, a felt, and three boards on top. Leave the post under this weight overnight. Then, using a small car-jack H-frame press, gradually increase the pressure to three-quarters of full pressure over a 30-minute period.
- For a post with a couching material between the sheets and using a small car-jack press, you can press immediately after sheet formation and go to full pressure within 15 minutes. If

you don’t have access to a hydraulic press, use any of the pressing techniques described in chapter 4.

DRYING: Separate sheets and brush onto wooden boards or metal sheets. Use a 3-inch-wide (7.5 cm) paintbrush and make sure the edges are attached firmly to the board. The sheets can also be air dried for a textured surface.

➤ If the edges seem too dry, mist them and tap them down firmly onto the drying surface. If the entire post seems too dry, mist the whole thing and leave it under a wet felt for 15 minutes to rehydrate. Then try attaching the sheets to boards again.

The Papermaker's Story

During a college internship at the Smithsonian Institution, Mina Takahashi worked on the restoration of a tapa (bark cloth) collection. A conservator who knew that Mina would be going to Japan for her junior year encouraged her to look into papermaking. She took the conservator's advice, visited several papermaking villages while she was in Japan, and became so fascinated that she returned for 2 years after college on a Watson Fellowship to study with master Japanese papermakers who practice the craft as it has been handed down over generations.

Mina is currently the executive director of Dieu Donné Papermill in the Soho art district of New York City. Dieu Donné, founded by Susan Gosin and Bruce Wineberg in 1976, is a not-for-profit hand papermill dedicated to the advancement of the art of hand papermaking by reinventing and adapting age-old techniques for contemporary art. Dieu Donné is a unique organization that provides a place for artists to work with handmade paper, a gallery that exhibits handmade paper art, a store that carries handmade papers and papermaking supplies, and educational programs for children and adults.

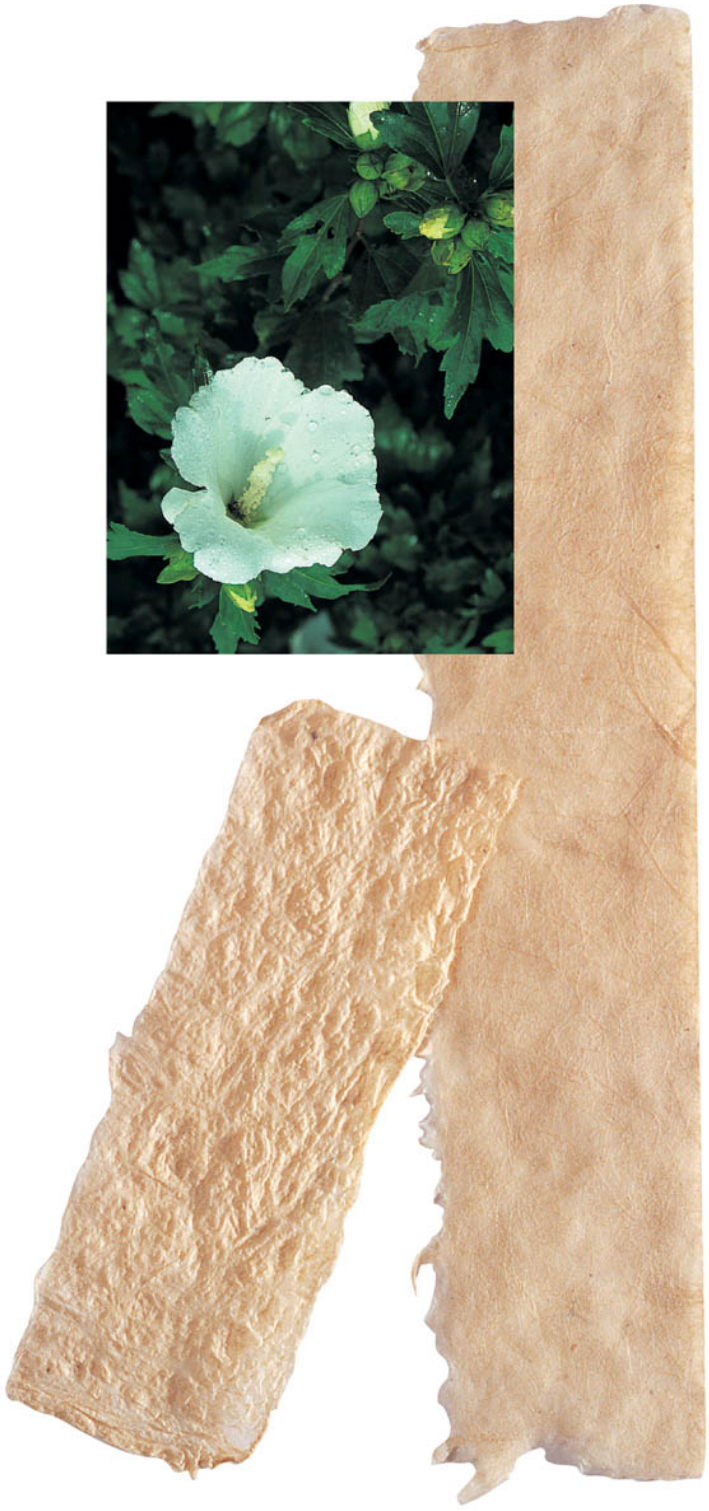
Mina teaches Japanese papermaking around the country, and during a course at Penland School in North Carolina, Mina and a group of her students discovered a grove of paper mulberry trees (called *kozo* in Japan) near a blinking-light intersection in a small town. Its striped

bark and its distinctively shaped leaves make it easy to recognize. They harvested branches from the small grove of young paper mulberry trees and took them to the school to process and make into paper. They chose branches that were similar in size and age so that the processing of the fiber would yield a consistent batch of pulp.

Rose-of-Sharon

Hibiscus syriacus

Recipe developed by Winifred Lutz



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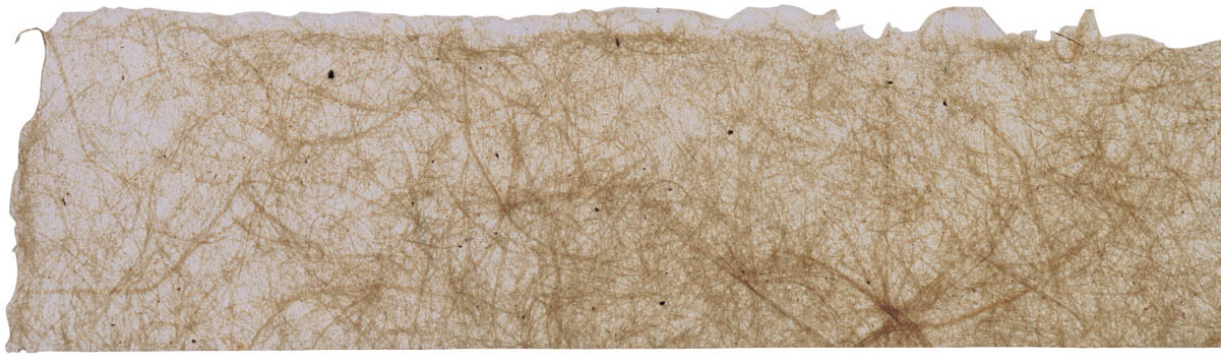


ABOVE: *View of paper as held up to a light*

PLANT FAMILY: Malvaceae

TYPE OF FIBER: Woody bast fiber

PLANT PART USED: Inner bark

AMOUNT OF FIBER: Unknown (this recipe calls for using fresh fiber that has not been dried)

ALKALI: Soda ash; the amount of alkali is measured based on the amount of liquid used instead of on the amount of dry fiber

VOLUME OF WATER: May vary; see below

HARVESTING: Harvest several ½- to 1½-inch-diameter (1.25 to 3.75 cm) branches and cut into even lengths that fit into a large cooking vessel.

ADDITIONAL FIBER PREPARATION: Steam the branches for at least 30 minutes, until the bark shrinks back and is easy to peel away from the woody core. Strip the bark from the woody core. Keep the peeled bark damp and scrape off as much of the black outer bark that has been loosened as possible.

➤ Winifred noted that the white bark softens quickly during cooking, but the green bark remains tough, requiring a longer cooking time. Scraping the green bark may reduce this time.

PRECOOKING PREPARATION: None. (The fiber is already damp.)

COOKING: Fill a nonreactive cooking pot with water sufficient to cover the fiber and allow it to move freely, measuring the water as you add it to the pot. Heat the water and add 15 grams (5.3 ounces) of soda ash per quart (liter) of water prior to boiling. When the soda ash is completely dissolved and the water boils, add the fiber to the solution piece by piece. Reduce to a simmer and cook, stirring the fiber every 30 minutes, until it pulls apart easily. Let the fiber stand for several hours in the cooking solution.

RINSING: In order not to lose the shorter fibers, rinse the fiber in a fine-mesh sieve until the water runs clear.

Beating: Hand beat with mallets until a pinch of fiber dispersed in water in a jar and shaken is free of clumps (see here). This will usually take about 40 minutes.

FORMATION AID: Add formation aid to the vat until the mixture feels viscous but not slimy (see Formation Aid).

SHEET FORMATION: Both Japanese-style nagashi-zuki and Western-style sheet formation are suitable for Rose-of-Sharon.

COUCHING/PRESSING: Couch onto felts. This fiber has insufficient wet web strength to form a Japanese-style post without felts. Use any of the pressing techniques described in chapter 4.

DRYING: Separate sheets and brush onto wooden boards or metal sheets. Use a 3-inch-wide (7.5 cm) paintbrush and make sure the edges are attached firmly to the board. Sheets can also be air dried for a textured surface.

The Papermaker's Story

Winifred Lutz is a sculptor who has always been interested in knowing how things are made. In high school, motivated by her interest in recycling, Winifred did a science project on papermaking, and she concocted papers from kitchen waste such as banana peels and pineapple tops. In graduate school, Winifred spent time in the papermaking studio and learned professional Western papermaking techniques. Later, on a travel grant in Japan and Korea, Winifred visited master papermakers and observed their craft. The exposure to Eastern papermaking techniques inspired her and led to her development of innovative techniques for casting her paper sculptures.

While in Japan Winifred was asked by master papermaker Kubota Yasuichi why Americans imported Japanese fibers for papermaking instead of using fibers from native North American plants. Winifred was intrigued, and she decided to search for North American plants that might be alternatives to Japanese plants. Some of her discoveries and recipes are included in Timothy Barrett's book Japanese Papermaking (see Reading List). Winifred's writing is an excellent guide to making Japanese-style paper with American plant fibers.

Rose-of-Sharon is a common garden shrub and happens to be suitable for both Japanese- and Western-style sheet formation.

Milkweed

Asclepias speciosa

Recipe developed by Lynn Amlie

©Arleen Lorrance

ABOVE: *Enlarged sample of dried milkweed stalk*

PLANT FAMILY: Asclepiadaceae

TYPE OF FIBER: Herbaceous bast fiber

PLANT PART USED: Inner fiber of the stalks

AMOUNT OF FIBER: 5 1/4 ounces (150 g) dry fiber

ALKALI: 1 ounce (30 g) soda ash (20% of dry fiber weight)

VOLUME OF WATER: 3 1/4 quarts (3 l)

HARVESTING: Harvest milkweed stalks in September before the seedpods open. Pick only the green stalks, because the black spots found on many stalks do not come off. A sticky milk oozes from the stalks when they are cut, so let them lie on the ground for at least 1/2 hour before transporting them, then remove the

leaves from the stalks. (Sixty-five stalks yield approximately 10.5 ounces (300 g) of dry fiber.

ADDITIONAL FIBER PREPARATION: Steam the stalks for at least 1 hour and strip the soft fiber from the woody core.

➤ Lynn noticed that although milkweed fiber separates easily from the core after 1 hour, the thin exterior skin still adheres to the soft fiber. She scraped off what she could, but felt that retting prior to steaming might facilitate removal of this skin (see here).

PRECOOKING PREPARATION: If the fiber has been dried, soak it in water overnight.

COOKING: Fill a nonreactive cooking pot with the water and add the damp fiber. Heat the water and add the soda ash prior to boiling. Simmer for approximately 1½ hours, stirring every 30 minutes, until the fiber pulls apart easily.

RINSING: In order not to lose the shorter fibers, rinse the fiber in a fine-mesh sieve until the water runs clear.

➤ Rinsing variation: Lynn devised a rinsing system that works well if you have the time: Drill holes around the top of a 5-gallon (19 l) bucket, just below the lip. Put the end of a garden hose in the bottom of the bucket, place your fiber in the bucket, and turn the hose on to a slow trickle. When the bucket fills with water, the water will start to drain out of the holes, but the fiber will stay in it. In some cases, small impurities will also

float away. If this is done outside, the sun will whiten the fiber. Since the water is running so slowly, it can take up to 3 hours to rinse completely. When done, the water should not feel slimy, and it should run clear.

BEATING: Hand beat with mallets for 40 minutes. The beaten fiber will probably look stringy, but it will separate in the vat when mixed vigorously.

FORMATION AID: Add formation aid to the vat until the mixture feels viscous but not slimy (see here).

SHEET FORMATION: Japanese-style nagashi-zuki.

COUCHING/PRESSING: Couch one sheet directly on top of the other, with a thread between each sheet, or couch onto a pellon or felt.

- For a post with threads between sheets, cover the post with a sheet of pellon, a felt, and three boards on top. Leave the post under this weight overnight. Then, using a small car jack H-frame press, increase to three-quarters of full pressure over a 30-minute period.
- For a post with pellon interleaving and using a small car-jack press, you can press immediately after sheet formation and go to full pressure within 15 minutes. If you don't have access to a hydraulic press, use any of the pressing techniques described in chapter 4.

DRYING: Separate the sheets and brush onto wooden boards or metal sheets. Use a 3-inch-wide (7.5 cm) paintbrush and make

sure the edges are attached firmly to the board. The sheets can also be air-dried for a textured surface.

➤ Note: More information on processing milkweed can be found in Winifred Lutz's appendix to Japanese Papermaking (see Reading List).

The Papermaker's Story

Papermaker Lynn Amlie was originally a ceramist, but when her fragile sculptures kept breaking, a friend suggested she try sculpting with handmade paper. She obtained some leftover paper pulp from her school's printmaking instructor and began to experiment with pouring pulp over armatures. Lynn later became interested in the longevity of paper and studied traditional papermaking techniques, traveling to Japan and Korea and researching the history and techniques of Asian papermaking.

Lynn completed graduate studies at the University of Iowa with Timothy Barrett and is now managing the papermaking research and production facility with him at the University of Iowa Center for the Book. During her graduate studies there, Lynn produced a limited-edition book, American Bast Fibers, which documented her work with three fibers: leatherwood, Alabama kozo, and milkweed.

Thistledown

Cirsium vulgare

Recipe developed by Maureen Richardson

©Dennis Frates

ABOVE: *Fluffy seed fiber of the thistle plant*

PLANT FAMILY: Compositae

TYPE OF FIBER: Seed fiber

PLANT PART USED: Seed hairs and some seeds

AMOUNT OF FIBER: For this recipe, collect enough fiber to fill a 1-gallon (4 l) bucket

ALKALI: Wood ash lye or soda ash; the amount is based on bringing the pH of the solution to between 10 and 12

VOLUME OF WATER: May vary; see below

HARVESTING: Remove the fluffy seed hairs and seeds from the pods that you collect along roadsides and in fields.

ADDITIONAL FIBER PREPARATION: None.

PRECOOKING PREPARATION: You can soak the fiber prior to cooking, but it is not essential.

COOKING: Place the fiber in a nonreactive pot and add wood ash lye plus enough water to cover the fiber so that it moves freely in the solution. The pH of the solution should measure between 10 and 12. Bring the pot to a boil and simmer for 1 ½ to 2 ½ hours.

RINSING: Put the fiber in a nylon mesh bag and submerge it into buckets of clean water until it no longer bubbles from the alkali.

Continue rinsing the fiber until the pH measures between 7 and 8. (A pH of 7 is neutral; a slightly higher, or slightly alkaline, pH counteracts the acidic contaminants present in our atmosphere; a pH higher than 8 can cause the paper to deteriorate prematurely.)

BEATING: Place a small handful of pulp in a blender that is three-quarters full of water and blend for 20 seconds. Repeat, blending some batches longer so the fiber lengths vary. Maureen finds that this makes the sheets more even during formation.

SHEET FORMATION: Western-style.

COUCHING/PRESSING: Press sheets using any of the systems described in chapter 4.

DRYING: Dry sheets using any of the techniques described in chapter 4.

➤ Couching, pressing, and drying variation: Maureen uses net-covered moulds without deckles. She has several moulds, and she lets her papers dry directly on them in an airy place. Maureen has found this successful for plants that are difficult to couch; this type of drying also eliminates the need to couch and press. When the sheets are completely dry, you can peel them off the moulds.

The Papermaker's Story

Maureen Richardson lives in England and has experimented with over 100 plants for papermaking. Her repertoire includes plants ranging from the inner bark of the lime tree to the fungus found on birch trees and the skins of fruit. She started out making paper from plants that had been used for textile or rope making in the past, like cotton, flax, ramie *(Boehmeria nivea)*, hemp, and sisal. She purchased these fibers at textile and weaving supply shops. She heard a fairy tale about a girl weaving cloaks out of nettles to throw over her brothers, who had been turned into swans — she tried tried making paper with nettles, with good results. This led to experiments with other plants from the countryside.

Maureen knew that cotton was a seed fiber, so she decided to try thistledown, another seed fiber. It does not make a strong paper by itself, although it does hold together. If you need a strong paper but like the look of thistle, try couching it on top of a stronger-fibered base sheet like abaca, cotton, or paper mulberry

Wood Ash Lye

Maureen makes her own alkali using ashes from her wood-burning stove. She built a simple lye maker following the

design in Timothy Barrett's book *Japanese Papermaking*. She has used the ash from elm, oak, and other woods. In addition to wood ash, you can use the ash of various straws and grasses. Maureen recommends straining 4 quarts (4 l) of boiling water through 2 pounds (900 g) of ash, which generally yields 2 quarts (2 l) of liquid. She checks the pH of the solution, which should be between 10 and 12 for proper cooking. If your wood ash lye does not have a pH of between 10 and 12, or if you don't want to make your own wood ash lye, you can use soda ash; add enough to bring the pH of the solution to between 10 and 12.

Hosta

Hosta fortunei

Recipe developed by Mary Leto

PLANT FAMILY: Liliaceae

TYPE OF FIBER: Leaf fiber

PLANT PART USED: Leaf and leaf stem

AMOUNT OF FIBER: 6 cups (1.5 l) of packed dry fiber

ALKALI: 3 tablespoons (45 ml) baking soda

VOLUME OF WATER: 10 cups (2.5 l)

HARVESTING: Collect leaves in fall after the flower stalks die back (although they can also be collected at any time of the year).

ADDITIONAL FIBER PREPARATION: None.

PRECOOKING PREPARATION: Rinse the leaves to get rid of sand and other debris. Soak the fiber in water for 24 hours prior to cooking.

COOKING: Fill a nonreactive cooking pot with the water and the hosta fiber. Heat the water, dissolve the baking soda in a small amount of cold water, and add it to the pot before it boils. Lower to a simmer and cook for 3 hours, until the leaves are easy to pull apart and resemble cooked spinach.

RINSING: Rinse the fiber well until the water runs clear.

BEATING: Hand beat with mallets for 15 minutes or in a blender by the handful for a few seconds.

SHEET FORMATION: Western-style.

COUCHING/PRESSING: Couch sheets onto any couching material and press sheets using any of the systems described in chapter 4.

➤ Pressing variation: Mary stacks her post between pieces of plywood and climbs on top of it for the initial pressing.

DRYING: Dry the sheets using any of the techniques described in chapter 4.

➤ Drying variation: After pressing, Mary puts a 5-gallon (19 l) bucket on top of the plywood and fills it with water to add weight. Every few hours, she removes the bucket, changes the felts, and puts the post under the weight of the water-filled bucket for another 2 hours. The sheets dry in about 24 hours.

The Papermaker’s Story

Mary Leto first started making paper to use for her prints, and her experiments led to a fascination with the medium. Now handmade paper is integral to her sculptures, prints, and books. When she found out she could use plants from her own yard, she was thrilled. She had found a process she could practice without having to travel or spend money — papermaking was a gift of nature she could not ignore. She shares her knowledge about making paper from plants as she teaches papermaking to gardeners at arboretums and botanical gardens.

One of Mary’s favorite plant fibers is hosta, which she gathers from her garden, because it can be found in most backyards and is easily gathered at almost any time of year. Instead of soda ash, Mary uses baking soda for cooking hosta fiber, which breaks down easily.

Mugwort Weed

Artemesia vulgaris

Recipe developed by Robbin Ami Silverberg

©Jerry Pavia

PLANT FAMILY: Compositae

TYPE OF FIBER: Grass

PLANT PART USED: Stalks

AMOUNT OF FIBER: 1 pound (500 g) dry fiber

ALKALI: 3 1/2 ounces (100 g) soda ash (20%of the dry fiber weight)

VOLUME OF WATER: May vary; see below

HARVESTING: Pull stalks from the ground.

ADDITIONAL FIBER PREPARATION: None.

PRECOOKING PREPARATION: Soak the fiber in cold water for 24 hours and rinse well.

COOKING: Fill a nonreactive cooking pot with water sufficient to cover the fiber and allow it to move freely. Heat water and add the soda ash to the water prior to boiling. Simmer for approximately 1 1/2 hours, stirring every 30 minutes, until the fiber pulls apart easily.

RINSING: Rinse the fiber thoroughly in a collander lined with mesh. (Note that the water won't ever run clear.)

BEATING: Hand beat the fiber with mallets for approximately 20 minutes.

➤ The paper sample shown here was beaten in a hollander beater for 25 minutes with the roll high — Robbin wanted a fine layer of the fiber, so the hollander made more sense than the usual hand beating. If you brought down the roll when beating grass fibers, they would virtually disappear.

SHEET FORMATION: Western-style.

COUCHING/PRESSING: Couch onto any couching material and press sheets using any of the systems described in chapter 4.

DRYING: Dry the sheets using any of the techniques described in chapter 4.

The Papermaker's Story

Robbin Ami Silverberg is proprietor of Dobbin Mill in Greenpoint, Brooklyn, where she produces unique and editioned artist books, large-scale installations, and a wide range of artist book collaborations, all which usually involve handmade paper. Robbin uses many grasses and weeds from her garden to make paper, and this recipe can be used for most types of grass or weed.

Pineapple

Ananas bracteatus

Recipe developed by Laura Anderson Barbata

ABOVE: *View of paper as held up to a light*

PLANT FAMILY: Bromeliaceae

TYPE OF FIBER: Leaf fiber

PLANT PART USED: Fibrous strands inside of the leaves. You can also use the strands found inside the leafy tops of the pineapple fruit.

AMOUNT OF FIBER: 1 pound (500 g) dry fiber

ALKALI: 4 ounces (110 g) soda ash (25% of dry fiber weight)

VOLUME OF WATER: 4 gallons (15 l)

HARVESTING: Cut the leaves at the base of the pineapple plants or remove the tops from the fruit.

ADDITIONAL FIBER PREPARATION: Scrape (decorticate) the leaves to obtain the long stringy fibers (see methods). In Venezuela, they tie a loop of rope (also made from the pineapple fiber) tightly around the middle of a fresh leaf and pull half the leaf through the loop, ripping the fleshy material from the stringy material. The leaf is then turned over and the process repeated.

Precooking preparation: Cut fibers into 1-inch (2.5 cm) pieces and soak in water for 24 hours.

COOKING: Fill a nonreactive cooking pot with the water and add the damp fiber. Heat the water and add the soda ash prior to boiling. Cook for 2 hours or more, until the strands of fiber are puffy and pull apart easily. (Note that these fibers are different from bast fibers: They will not pull apart quite as easily as bast fibers do.) Let the fiber sit in the solution overnight.

RINSING: Rinse the fiber thoroughly until the water runs clear.

BEATING: Hand beat the fiber with mallets for approximately 20 minutes, until a pinch of fiber dispersed in water in a jar and shaken is free of clumps (see here).

SHEET FORMATION: Western-style or Japanese-style.

COUCHING/PRESSING: Couch onto any couching material and press sheets using any of the systems described in chapter 4.

DRYING: Dry sheets using any of the techniques described in chapter 4.

The Papermaker's Story

Laura Anderson Barbata is a sculptor who had an exhibition in Venezuela a few years ago. While there, she extended her visit to see other parts of the country. Her artist friends organized a trip to the Amazon rain forest, where she met indigenous people whose work with wood echoed her own artistic approach.

During her visit, she spent some time alone with some village children of the Yanomami tribe. In an effort to communicate, Laura gave each child a sheet of handmade paper, which she had with her, and a pencil, thinking they might find a way to communicate. To her amazement, the children did not use the paper as a writing surface. Instead, they pointed at grasses in the field, recognizing that the paper was made from plants. Each child had a different reaction to the paper. One child dropped his sheet and watched it float through the air. Another folded his sheet and used it as a ground mat. Another held it up to the light to admire its translucent quality. The children saw the paper as an object itself, rather than a writing surface.

Through a series of visits to the area, Laura decided to teach the Yanomami tribe how to make paper, although she had never done it herself. Together, they set a goal to make paper from local fibers, using locally built equipment. Between trips, Laura tested fibers and learned how to make paper at Dieu Donné Papermill in New York City. Now, a few years later, three different indigenous

groups are making paper for use in their schools; some communities are documenting their history, which until now had only been orally passed down or written about by outsiders and published in other languages as anthropological studies; and some of the communities are making salable products from their paper.

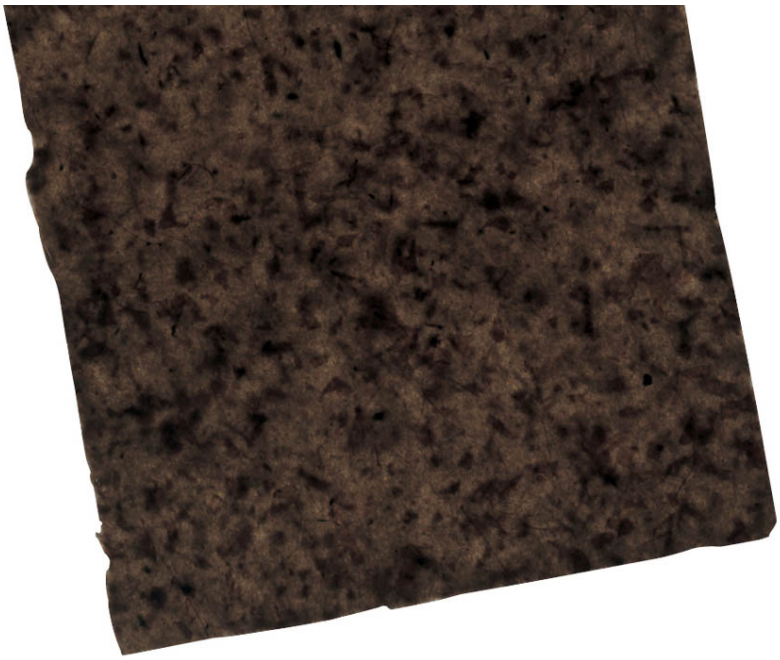
Each community has experimented with many plant fibers that grow in their region, and a fiber common to all of the communities is from the leaves of the pineapple plant.

Yucca Paper

Yucca filamentosa

Recipe developed by Lilian Bell

©Ben Phillips



ABOVE: *View of paper as held up to a light*

PLANT FAMILY: Agavaceae

TYPE OF FIBER: Leaf fiber

PLANT PART USED: Fibrous strands inside the leaves

AMOUNT OF FIBER: Unknown (this recipe calls for using fresh fiber that has not been dried)

ALKALI: Lye; the amount of alkali is measured based on the amount of liquid used instead of on the amount of dry fiber. Before using lye, reread the safety precautions.

VOLUME OF WATER: May vary; see opposite page

HARVESTING: Harvest the outer leaves of the plant, leaving the inner leaves intact so the plant can continue growing for future harvest. Both fresh (green) and dry (brown) leaves can be used, although the brown dry ones have to be cooked or retted to extract the fiber. This recipe calls for green leaves. Collect leaves that are at least 24 inches (60 cm) long from plants that are 2 or 3 years old.

ADDITIONAL FIBER PREPARATION: Scrape the leaves using one of the following techniques:

- Scrape the green fleshy material from each leaf, using a large handheld shell to obtain the long stringy white fibers. (Lilian

feels this yields the whitest paper.)

- Pound the leaves with a mallet or hammer to break the outer skin. Some green matter will remain attached, but it will dissolve when cooked. (Lilian does not care for this method, because it breaks the fibers.)
- Lilian has an aquaintance who obtained his pineapple fiber by strewing the leaves on his driveway and driving over them with his car.

PRECOOKING PREPARATION: Soak the fiber in clear, cold water for 24 hours prior to cooking.

COOKING: Fill a nonreactive cooking pot with water sufficient to cover the fiber and allow it to move freely, measuring the water as you add it to the pot. Add 1 tablespoon (15 ml) of lye per quart (liter) of water to the unheated water, first mixing the lye with a small amount of cold water. Heat the water and simmer for 2 hours or more, testing the fiber for doneness every ½ hour as follows: Remove a few strands of fiber from the cooking solution, rinse them, and put them in a blender filled with water. The fiber is done cooking if it disperses evenly in the blender without knotting or clumping.

RINSING: Line a colander with mosquito netting, old sheer window curtains, or a nylon paint strainer bag and rinse thoroughly until the water is clear. If time allows, leave the fiber soaking in clear water overnight to make sure any residual alkali is removed.

BEATING: Using a blender, cut the strands into ½- to 1-inch (1.25 to 2.5 cm) pieces. Make a plum-size ball, and place it in the blender with 3 cups (750 ml) of water, and blend for 1 minute. Repeat to process the rest of the pulp.

SHEET FORMATION: Western-style, Japanese-style nagashi-zuki, or deckle-box.

COUCHING/PRESSING: Couch onto any couching material and press sheets using any of the systems described in chapter 4.

DRYING: Dry sheets using any of the techniques described in chapter 4.

➤ Couching, pressing, and drying variation: After couching onto cotton or pellon fabric, Lilian rests her sheets, paper-side up, on a towel for 1 minute to get rid of some moisture. Next, she lays the sheet of paper, paper-side down, onto a wood or Formica board with the couching material still attached, and rolls over the couching material with a brayer or a wooden roller from the center out. She then removes the couching material and lets the sheets air dry on the boards. The paper dries flat and pressed in about 24 hours. When Lilian uses her sheets for sculpture, she applies the damp, freshly made sheets directly to her forms, without pressing or drying.

The Papermaker's Story

When Lilian Bell began looking for papers to use for her artwork, she found that the papers she purchased were never the right color, texture, or size, so she explored making her own. Lilian was an assemblage artist working with found materials and objects, so it seemed natural to her to start out making recycled paper. As she became acquainted with the thin, lustrous Japanese handmade papers and learned that they were made from plants, she decided to try such papermaking herself. She found plant fibers particularly appealing because they required little equipment. Already an avid gardener, Lilian began growing her own papermaking plants.

Lilian's primary focus has been to make paper for her sculptures. She has traveled extensively, studying various papermaking techniques and traditions, and she has written two books: Plant Fibers for Papermaking and Papyrus, Tapa, Amate and Rice Paper (see Reading List), in addition to making wall reliefs, artist books, and installations.

Yucca is one fiber Lilian grows in her garden.

Lye Cautions

Be very careful when using lye, as it can burn you if it comes in contact with your skin. Before adding lye to your cooking pot, first mix it with a small amount of cold water. Then pour the solution into the unheated cooking water before adding the fiber. (Lye can splatter explosively if added directly to hot water). Remember that lye in the United States is diluted. If using lye in or from another country, ask whether it is pure and if so, use less.

Seaweed

Ulva lactuca, Zostera marina, and Phyllospadix spp.

ABOVE: *View of paper as held up to a light*

ABOVE: *Fibrous green seaweed*

PLANT FAMILY: Ulvaceae and Zosteraceae

PLANT PART USED: Use any green seaweed (you can add other colors for variety, but the green kinds are the most fibrous). Do not use kelp (large brown seaweeds), because it turns to mush after cooking. Seaweed paper can be difficult to couch, so you might want to add a small amount of another fiber, such as paper mulberry, abaca, or cotton. (Use 9 parts seaweed to 1 part other fibers.)

AMOUNT OF FIBER: Fill a 16-quart (15 l) pot half full with loosely packed fiber

ALKALI: 8 ounces (240 ml) soda ash

VOLUME OF WATER: 16 quarts (15 l)

HARVESTING: Collect seaweed along the beach.

ADDITIONAL FIBER PREPARATION: None.

PRECOOKING PREPARATION: Soak fiber in water overnight to remove sand and salt water. Rinse thoroughly.

COOKING: Fill a nonreactive cooking pot with the water and add the damp fiber. Heat the water and add the soda ash prior to boiling. Simmer for approximately 1½ hours, stirring every 30 minutes, until the fiber pulls apart easily.

RINSING: In order not to lose the shorter fibers, rinse the fiber in a fine-mesh sieve until the water runs clear.

BEATING: Using a blender, cut the seaweed into 1-inch (2.5 cm) pieces. Make a plum-size ball, place it in the blender with 3 cups (750 ml) of water, and blend for a few seconds. Repeat to process the rest of the pulp.

FORMATION AID: Use a small amount of formation aid.

Sheet formation: Japanese-style nagashi-zuki or Western-style.

➤ Sheet-formation variation: Marilyn uses a combination of Eastern and Western techiniques. She has a Western-style mould and deckle, upon which she places a flexible mesh that resembles a su. She adds a small amount of formation aid to the vat and forms sheets using the nagashi-zuki technique. The flexible screen is then lifted from the mould surface and the sheets are couched directly onto boards. This eliminates the need for pressing.

COUCHING/PRESSING: Couch onto any couching material and press sheets using any of the systems described in chapter 4.

DRYING: Dry the sheets using any of the techniques described in chapter 4.

The Papermaker's Story

Marilyn Wold has been making paper for 20 years, experimenting with many fibers in locations where she has lived, particularly Oregon and Hawaii. She uses a mechanical stamper to beat many of her fibers, which her husband designed based on a model he saw in Timothy Barrett's book Japanese Papermaking.

While on an outing to the rugged southern Oregon coast in search of agates, Marilyn saw long rows of colorful seaweed, and she wondered if she would be able to make handmade paper from it. She collected the seaweed and succeeded in making paper.

Achieving Perfection

For some papermakers, a perfect sheet of paper reveals hardly any distinguishable fibers when held up to a light. Many papermaking artists and admirers, however, consider the unusual and unique arrangement of fibers in sheets, as shown in the seaweed paper to the left and in other backlit papers in this section, to be one of the most beautiful and appealing features of paper handmade from plants.

Paper from Preprocessed Fibers

ABOVE: *LEFT: cotton linters; RIGHT: preprocessed sheets of abaca fiber*

Amount of dry fiber: ½ pound (230 g), equal to one or two sheets of preprocessed pulp

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BEATING:

- Cotton or recycled paper: Tear sheets into 2-inch (5 cm) squares; soak these squares in cold water for 1 hour.
- Abaca: Abaca is difficult to tear when dry, so you will need to soak the sheets first, then tear into squares.

In either case, fill the blender two-thirds full of water and add four squares of wet sheet pulp. Blend for a few minutes until the mixture has the consistency of oatmeal. Pour the blended pulp into a bucket and continue processing the rest of the pulp.

SHEET FORMATION:

- Cotton or recycled paper: Western-style.
- Abaca: Western-style, or Japanese-style nagashi-zuki.

COUCHING/PRESSING: Couch onto any couching material and press the sheets using any of the systems described in chapter 4.

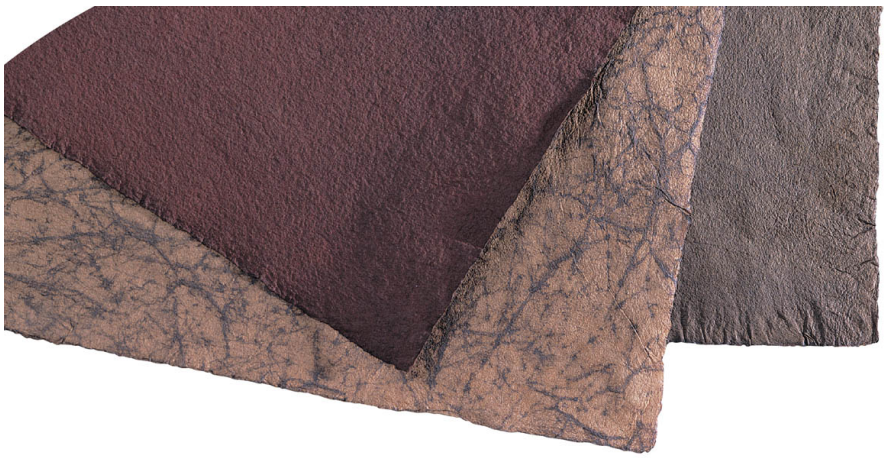
DRYING: Dry the sheets using any of the techniques described in chapter 4.

Many preprocessed plant fibers are available from papermaking suppliers. They are easy to beat in a blender, a whiz mixer, or a Hollander beater. Cotton and abaca are the fibers most commonly found in the form of preprocessed sheets. Cotton linter, which makes a paper that is opaque and soft, is a seed-hair fiber collected from the cotton plant after it is ginned for textiles. Abaca, a long, strong fiber, is made from the fiber in the leafstalks of a banana plant that grows in the Philippines and South America. Both of these pulps are easy to work with and make fine sheets of paper themselves. They are also excellent to mix with other pulps to add strength or to make sheet formation easier. If you are having a hard time working with a particular plant fiber — if it just won't form into sheets of paper or if it is difficult to couch — try adding a small amount of cotton or abaca to your vat.

Both cotton and abaca fibers can be processed similarly in a blender using the following recipe. This recipe will also work for recycled paper.

Natural Dyeing

Bridget O'Malley of Cave Papers in Minneapolis contributed this recipe for black walnut dye. The secret of Bridget's rich brown color is brushing the dye directly onto sheets of dry paper, rather than coloring the pulp in the vat. This brushing technique can be used for other natural dyes as well.



ABOVE: *Black walnut dye can create many different effects depending upon the paper it's applied to and how it is applied.*

MATERIALS AND EQUIPMENT

- 1 pound (500 g) of black walnut husks (without nuts)
- 1 1/4 gallons (5 l) water
- 2-gallon (8 l) bucket or pot
- Stove or hot plate

Strainer

Wide paintbrush

Gelatin sizing

INSTRUCTIONS

1. Soak the dried black walnut shells in the water overnight.
2. Boil the shells in the same water for 1 hour. Allow to cool.
3. Strain the solution through a strainer into a bucket or pot, collecting the dye solution while removing the shells. You can reuse the shells to make a second batch of weaker dye.
4. Brush the walnut dye onto sheets of dry paper. If the color isn't dark enough, apply a second coat. Otherwise, add more husks when making the solution. If the color is too dark, add water to dilute it.
5. Hang the sheets to dry.
6. Apply one coat of gelatin sizing after the walnut dye is dry to ensure that the color will not rub off. (To make your own gelatin sizing, see here.)

Fresh Flower Petal Paper

Make beautiful decorative sheets of paper by adding flower petals to your base pulp. Many flower petals bleed when they get wet, and this discoloration can spread and can damage your sheet of paper. Blanching fresh plant parts in hot water prior to adding them to the vat can prevent bleeding, though, and it will also hydrate the material so that it will mix into the pulp.

MATERIALS AND EQUIPMENT

- Papermaking equipment
- Prepared pulp
- Fresh flowers
- Scissors
- Pot for boiling
- Stove or hot plate

INSTRUCTIONS

1. Gently remove the petals from their stems, either picking them by hand or using scissors.
2. Bring a pot of water to a boil. Add the petals and blanch them for 5 minutes.
3. Strain the petals and add them to your vat of pulp. You can vary the amount of petals you add to make a subtly or highly decorative sheet.

   ➤ When you're making sheets, remember to continually stir the pulp in the vat to ensure that the decorative items are evenly distributed throughout.
4. Make your sheets of paper, and then press and dry them.

Variations

You can add many other decorative elements to your base pulp, as long as they are small and lightweight enough that they do not sink to the bottom of the vat. Decorative items should also be flat, so that they do not cause problems when you press. Glitter, threads, or small swatches of fabric are a few suggestions — the items just need to float amid the pulp so that they get picked up on the mould when you form a sheet. (Nonplant decorative items do not need to be blanched.) Here are some other decorative-item ideas:

- Confetti
- Strands of thread
- Leftover plant pulp
- Glitter
- Leaves
- Ribbon

Collage Paper

You can make a collage on the surface of a wet sheet of paper before you press and dry it, attaching photographs, drawings, and other items directly onto the sheet. All you need are some collage items, and methyl cellulose to adhere the items to the surface of the sheet.

MATERIALS AND EQUIPMENT

Papermaking equipment

- Prepared pulp
- Collage material (photos, ribbons, string, papers, drawings, and so on)
- Glue brush
- Methyl cellulose glue (see recipe below)
- Clean container for mixing methyl cellulose

INSTRUCTIONS

1. Make a sheet of paper and transfer it to a couching surface.
2. Methyl cellulose can be applied to your collage material in two ways: Either brush it onto the back of the items you are collaging, or submerge the items in a container of methyl cellulose (the latter method works well for items that are difficult to brush with glue — a feather, for example).
3. Place the collage items onto the sheet of paper.
4. Press the sheets and dry them. If you dry your sheets on boards, place the collaged surface away from the surface of the board to prevent sticking.

    ➤ Some collage items might bleed when they get wet and are pressed onto the sheets of paper. This bleeding could discolor and/or soak through your felts, staining them along with other sheets of paper. To prevent such

bleeding, stack more than one felt between sheets of paper. You should also wash your felts immediately after use. You may also wish to place additional felts between sheets if your collage items are slightly three dimensional. This will prevent impressing the shape and texture of the items into other sheets in your post of paper.

Recipe for Methyl Cellulose

You can obtain methyl cellulose in powder form from any papermaking supplier or in art-supply stores. To make a solution, sprinkle 8 teaspoons (40 ml) of methyl cellulose into 1 cup (250 ml) of boiling water, then add 1 cup (250 ml) of cold water and mix well. Let the solution cool to room temperature. It will thicken and become the consistency of honey.

Embedding Objects in Sheets of Paper

Embedding is a process of sandwiching materials between sheets of paper. You can embed items such as string or wire to add structure to a sheet of paper or to create a three-dimensional surface. You can also couch a thin translucent sheet of paper over embedded items so that they will be visible. In order to be able to press the sheet properly, the embedded items must be no thicker than ⅛ inch (.3 cm).

When couching one sheet of paper on top of another, you will need a guide or jig for lining up your sheets.

MATERIALS AND EQUIPMENT

- Papermaking equipment
- Prepared pulp
- Embedding items
- 1/4 inch-wide (.6 cm) tape

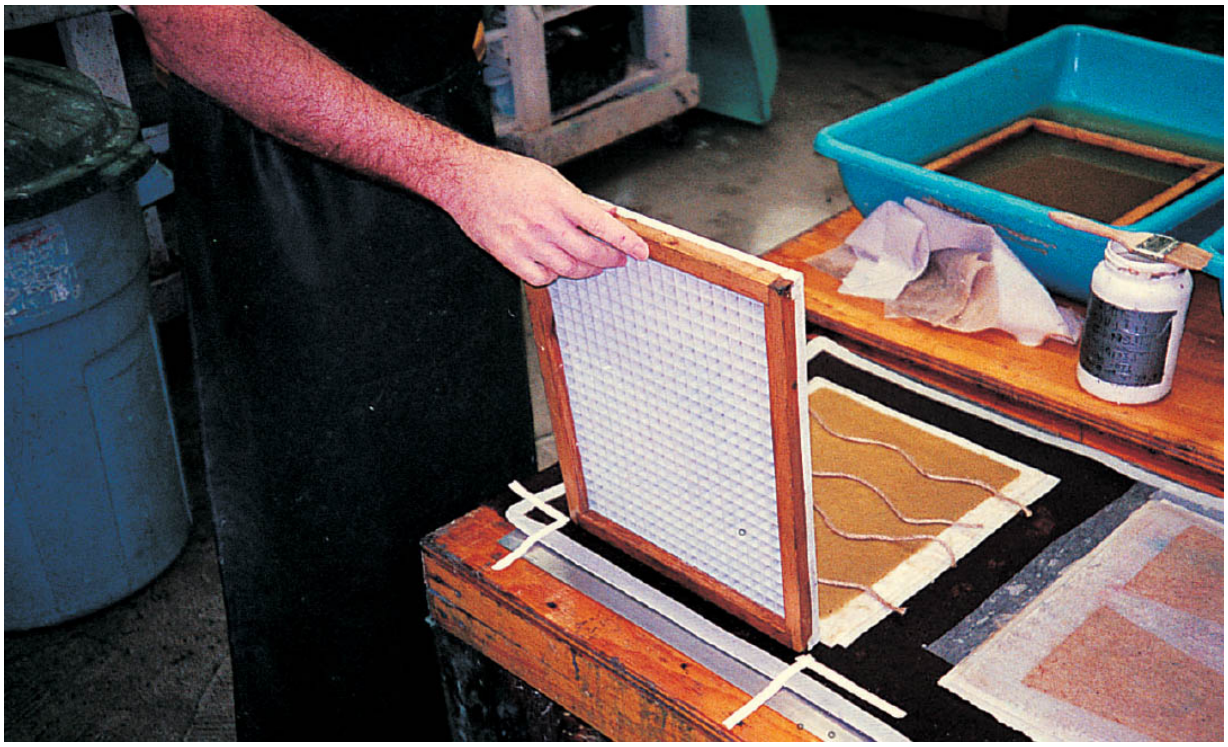
INSTRUCTIONS

1. While your couching surface is still dry, lay your mould facedown in the middle of it. Using ¼-inch-wide (.6 cm) strips of waterproof tape that are 2 to 3 inches (5 to 7.5 cm) in length, make a couching guide by marking two adjacent corners.

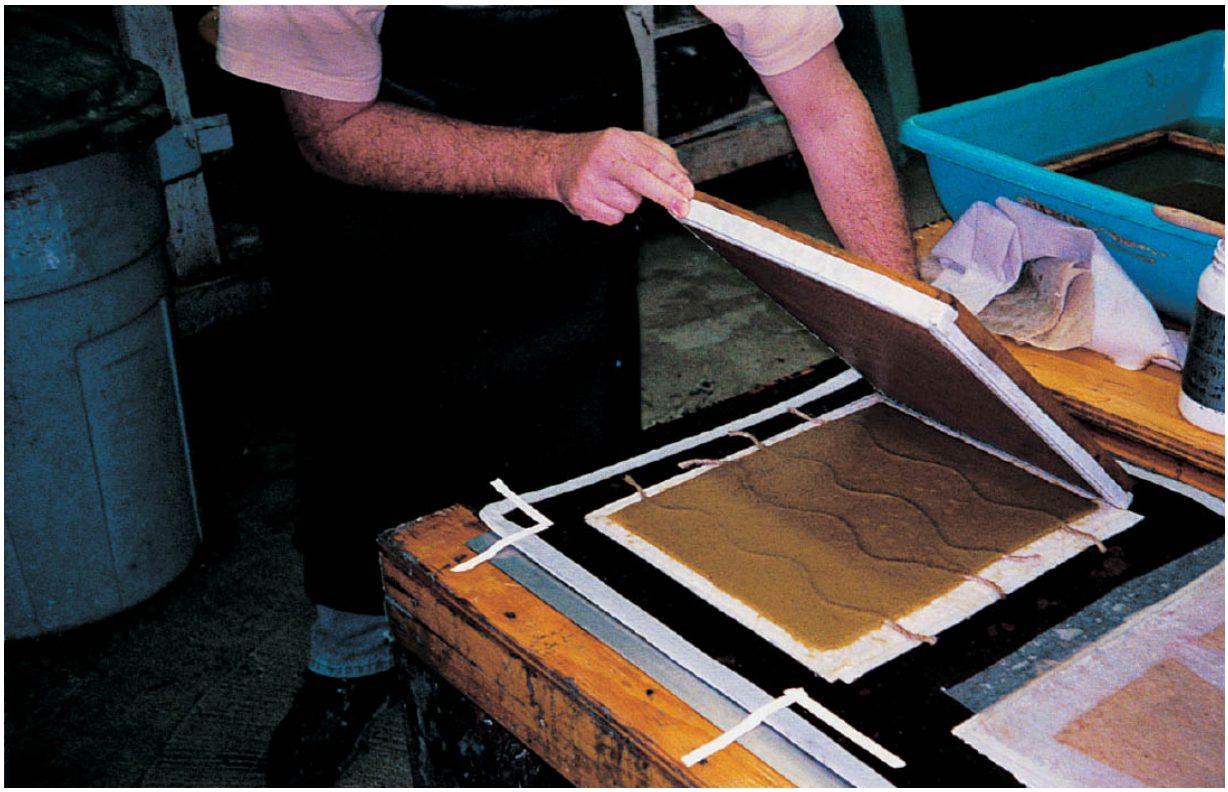
2. Make a sheet of paper and couch it, laying one side of the mould down along the guides.

3. Lay the embedding items on top of the sheet.

4. Make a second sheet of paper and couch it on top of the first sheet, using the guides to line up the two sheets.



ABOVE: *To couch the second sheet directly on top of the first sheet, align the mould with the couching guide.*



ABOVE: *The objects are then sandwiched between the two sheets and will become firmly embedded as the sheets dry.*

Vegetable Papyrus

Egyptian papyrus is made by overlapping pieces of the stalk of the papyrus plant, then pounding or pressing the pieces together. The technique can also be used with slices of common household vegetables to make vegetable papyrus. When pressed and dried, the intricate patterns of the seeds and veins in these vegetables become visible.

When choosing vegetables, use types that are firm when raw, but soft when cooked. I have used zucchini, squash, turnips, onions, beets, carrots, parsnips, and green and red peppers. I've also worked with such fruits as apples, star-fruits, and oranges.

MATERIALS AND EQUIPMENT

- Vegetables and/or fruits
- Sharp knife
- Cutting board
- Pot of boiling water
- Stove or hot plate
- Strainer and/or slotted

spoon

Newspaper or blotters

Old couching material

Press

Vegetable steamer (optional)

Grater (optional)

Peeler (optional)

INSTRUCTIONS

1. Remove carrot tops, apple stems, and other inappropriate parts, if you wish. Slice the vegetables into ¼-inch (.6 cm) rounds. (If you have seen vegetable papyrus, you might think that the vegetables were sliced extremely thin, but it is the pressing that makes them thin.)

2. Drop the sliced vegetables into the boiling water. Cook the rounds until they are soft to the prick of a fork. Softer vegetables (zucchini or squash) will need only a couple of minutes, but firmer ones (carrots or beets) may require up to 10 minutes. When they're done, remove the rounds from the water with a slotted spoon, or strain them.

3. Don't use good felts for this project — some vegetables stain. Arrange the vegetable rounds on your felt, making sure they overlap by at least ¼ inch (.6 cm). Place a second felt on top. Since the vegetables are still quite thick,

either press the sheets individually or stack several felts between the layers. Press the sheets.

4. Remove the sheets from the press and transfer them to dry sheets of pellon. I recommend placing them between sheets of pellon and drying them in a stack dryer or a press. If you air dry vegetable papyrus, it will shrink, resulting in wavy, potato-chip-like pieces.

Variations

- Grate or peel the vegetables or slice them lengthwise.
- Mix and match vegetables to make a multicolored sheet.

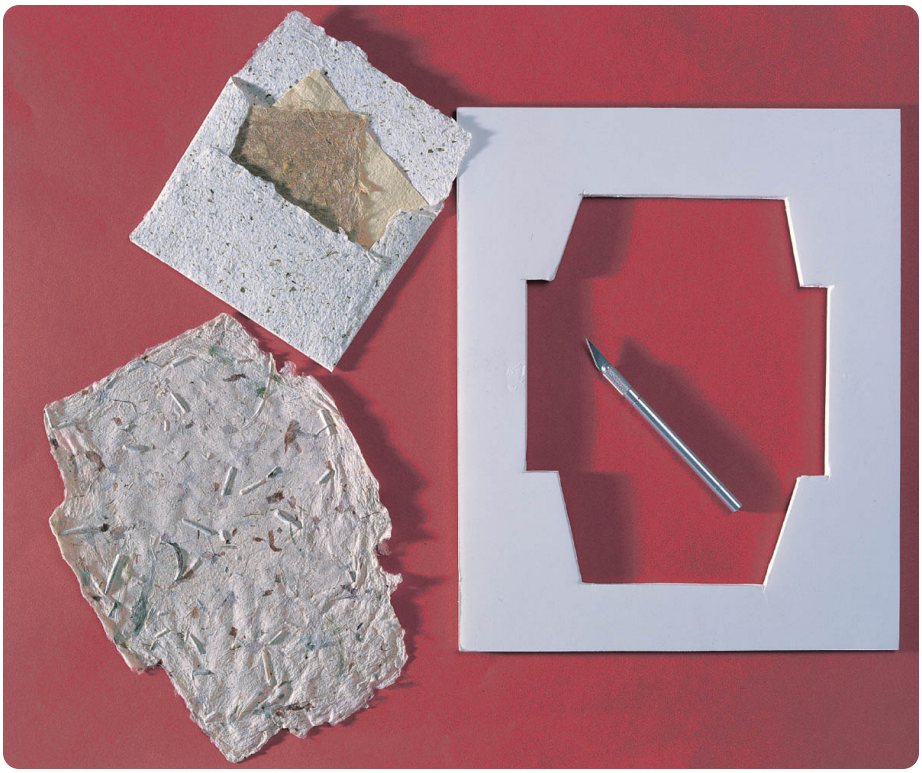
Papyrus

Papyrus, used in ancient Egypt, Greece, and Rome, is the material most people commonly think of when they think of ancient writing materials. While most people think papyrus is paper, in fact, it is not. True paper requires that the raw material must be macerated, or beaten, and broken down into tiny fibers, mixed with water, and formed into sheets on a screen surface which catches the fibers as the water drains through the holes in the screen. As the water escapes, the individual fibers interlock and bond together, forming a sheet of paper that is then pressed and dried.

Although the papyrus plant can be macerated and formed into sheets on a screen and made into sheets of paper, traditional papyrus was made by cutting strips of the plant's stalk into lengths and overlapping them side by side. A second layer of overlapping strips was placed on top of the first layer, with the strips running perpendicular to those on the bottom layer. These two layers were then pounded and laminated together.

Shaped Paper Envelopes

The perfect way to create envelopes, cards, and other distinctively shaped papers is by making a custom deckle that fits on top of your mould. When you design your custom deckle, remember that large, smooth-edged shapes work the best, because pulp tends to get stuck in the little crevices of intricate designs.



MATERIALS AND EQUIPMENT

Papermaking equipment

Prepared pulp

Pencil and paper

Custom deckle materials such as artcore (a plastic foam board), Foamcore (if you cover it with waterproof tape, it will last longer), or $^{3}/_{8}$"-thick Styrofoam (available from lumberyards)

Utility knife

Waterproof tape (optional)

INSTRUCTIONS

1. Plan a design for your deckle. Make sure that it is the same size or smaller than the screen surface of your mould (the inside dimensions of your original deckle).

2. Using a cutting knife, cut the custom deckle material to the outside dimensions of your mould.

3. Trace or draw the custom deckle design onto the custom deckle material and cut the design out.

   ➤ To plan the proper dimensions for an envelope, undo a prefabricated envelope and trace around it on your custom deskle material

4. Replace the traditional deckle with the custom deckle and set it on top of the mould.

   ➤ If you will be making many sheets of paper, you can create a sturdier deckle by taping your custom deckle into your traditional deckle. To do this, cut the custom

deckle to the inside dimensions of the traditional deckle and cut out your design. Then tape the custom deckle to the traditional deckle while holding it flat against the surface of the mould. Turn it over and tape the edges together on the bottom side.

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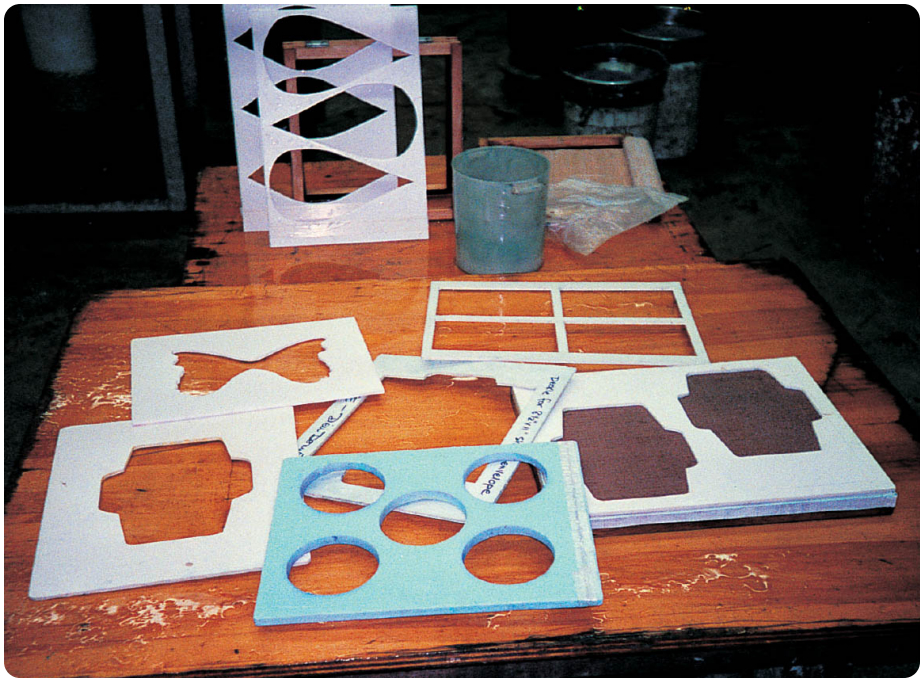
5. Make sheets of paper, press, and dry them.



ABOVE: *You can make paper in any shape or make multiple sheets in a single dip using a custom deckle.*

Multipaneled Handmade Paper Lampshade

When you select a frame for this unique paper shade, make sure the bulb will be at least 2 inches (5 cm) away from the shade at every point. With paper shades, never use bulbs of more than 40 watts.

MATERIALS AND EQUIPMENT

Papermaking equipment

Prepared pulp

Custom deckle material

Old lampshade frame or purchased frame (see Resource Guide)

PVA glue (polyvinyl acetate)

Glue brush

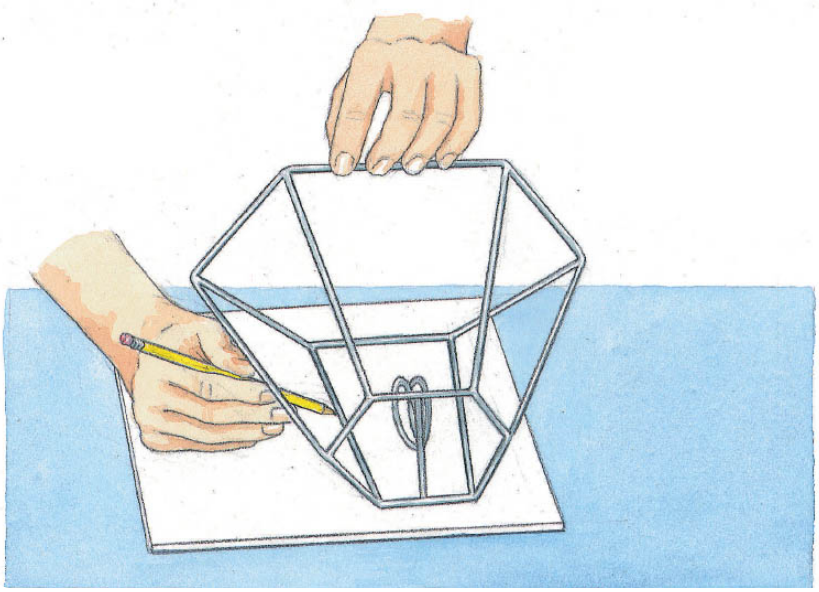
Pressing equipment (including felts)

Small painter's spatula

Cutting knife

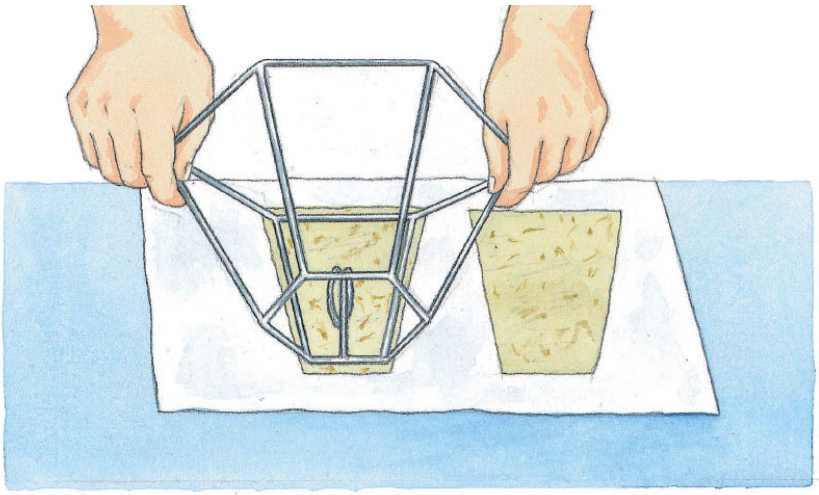
INSTRUCTIONS

1. Set one panel of your shade on a piece of custom deckle material and trace around the outside edge of the panel. Add 1/4 inch (.6 cm) all around to make the sheets large enough to wrap around the wires. Then cut out the panel with a cutting knife.

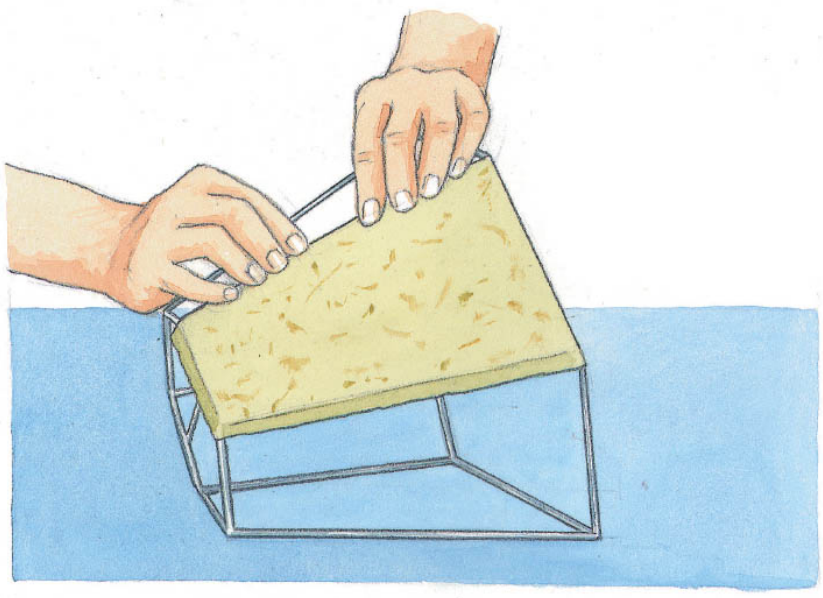


2. Use the custom deckle to pull paper sheets (see here) for each panel (and make a few extra so that you can practice the wrapping technique). Press the sheets lightly, then loosen them from the felts.

3. Using a brush, apply PVA glue to all four edges of one section of the armature, coating all sides of the wires. Place the glued section of the armature onto one of the shaped paper panels, making sure to center it.



4. Using a small painter's spatula or a dull, thin flexible implement, gently lift each edge of the paper and wrap it snugly around the wire armature. Neatly tuck the ends underneath the wire. Apply more glue if necessary. If the paper is not securely attached, it will pop off of the wire as it dries.



5. On subsequent panels, overlap one edge onto the previous panel. The last panel will overlap on two edges.

6. Suspend the lampshade to dry. Depending on the humidity and the paper thickness, it will take approximately 24 hours to dry.

Accordion-Fold Book with Pockets

This is a simple pocket accordion book structure with pockets, in which you can store samples of your plant papers. Make this book with dry paper, and adjust the size according to the samples you wish to store. You need to make sure that the text paper will fold easily, and the grain (the natural fold of the paper) should run in the direction of the book's spine. The cover paper should be sturdy. My 11-by-14-inch sheet with five folds ended up with four pockets on each side of the accordion.

MATERIALS AND EQUIPMENT

- Text-weight paper
- Cover weight paper
- Swatches of plant papers
- Cutting knife or scissors

PVA glue

Bone folder

Pencil

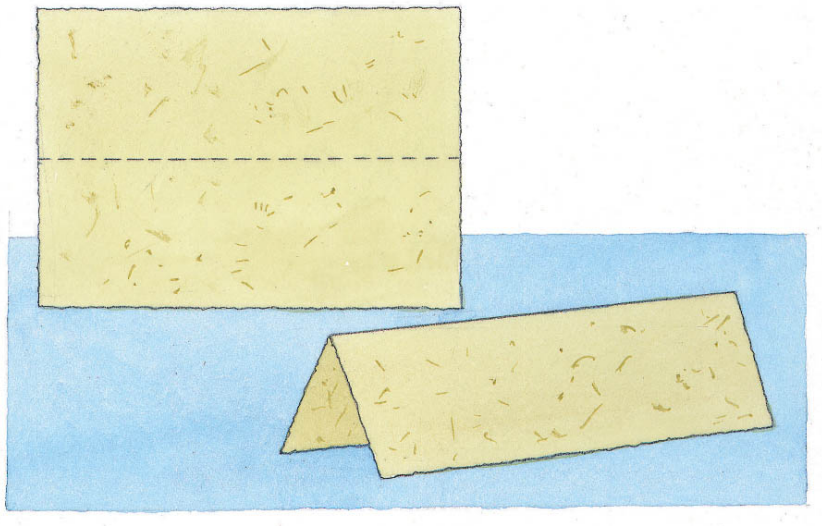
Triangle

Ruler

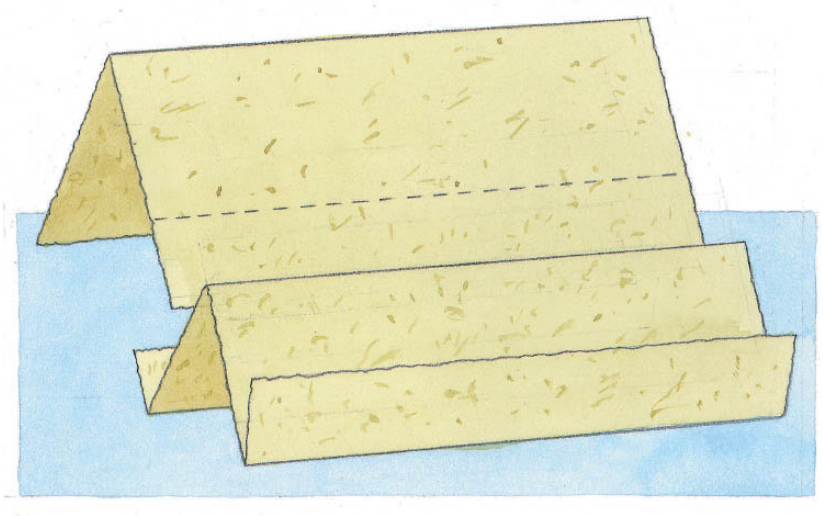
Ribbon

INSTRUCTIONS

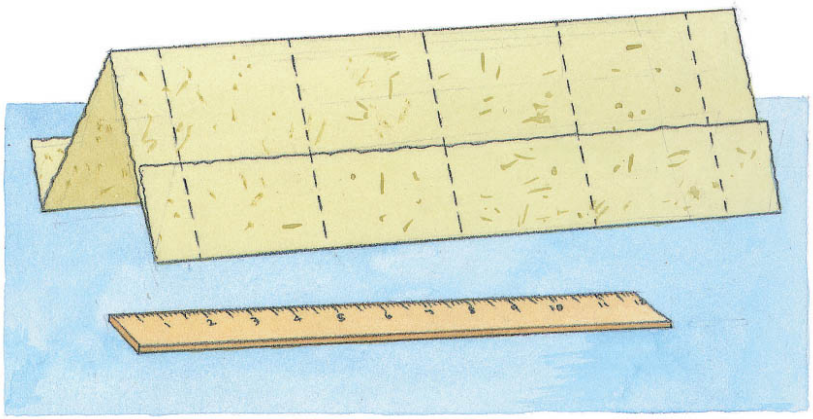
1. Fold the sheet of text-weight paper in half lengthwise, and crease the fold with a bone folder.



2. At the open edge, mark the sheet 1 ¾ inches (4.5 cm) from the bottom edge, and fold the paper back on itself to create the pockets. Turn the paper over and repeat.

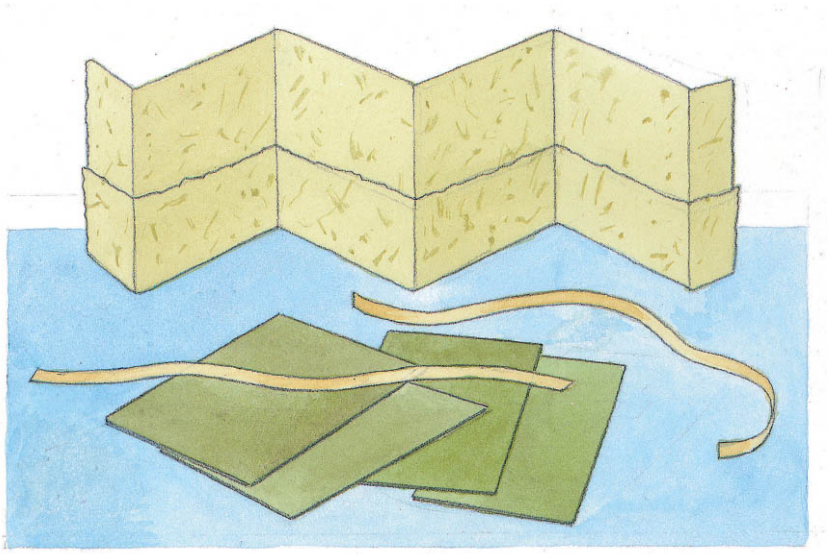


3. Place a ruler along the top edge (the V-fold) of the sheet and mark the following points: 1 inch (2.5 cm), 4 inches (10 cm), 7 inches (17.5 cm), 10 inches (25 cm), and 13 inches (32.5 cm).



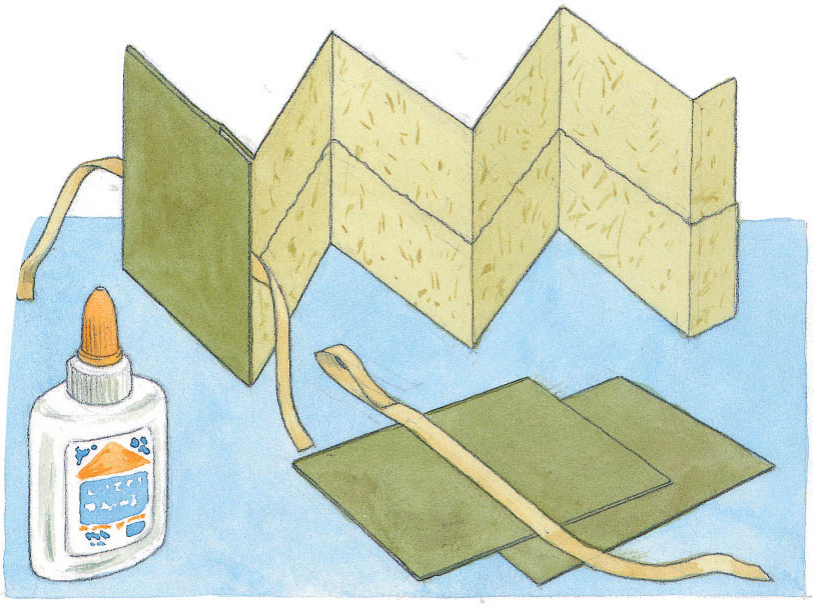
4. Fold the sheet in half at the 7-inch (17.5 cm) mark. Fold the paper back on itself at the 4-inch (10 cm) and 10-inch (25 cm) marks. Continue accordion folding, folding the tabs back the other way. Crease all folds with the bone folder.

5. Cut four pieces of cover paper to slightly larger ($1/16$ inch, or .2 cm) than the height and width of your text block. Cut two pieces of ribbon to at least 12 inches (30 cm) in length.



6. Apply glue to the center of two cover panels and attach the ribbons, centering them horizontally.

7. Apply glue to the outer side of a tab on the accordion and place the ribbon side of one cover on it. Then apply glue to the inner side of that cover sheet, coating the tab, ribbon, and cover, and place a plain cover piece on top, sandwiching the tab and ribbon between the cover sheets. Put the cover under pressure until the glue dries. Repeat with the second set of covers on the tab at the other end of the accordion.



Appendix: Papermaking Plants

This guide to plants is divided into the three common papermaking categories: bast, leaf, and grass fibers. The bast fibers are further separated into their groups of woody, herbaceous, and petiole, which require different processes for obtaining the fiber. There are also lists of fibers you can find in your grocery store and fibers you can purchase.

Some plants, such as cattail, appear in two categories, because two parts of the plant (the leaf and the stalk) can be made into paper. Other plants that might be classified by a botanist as herbaceous bast, like mugwort, appear in the grass category because they can be processed like a grass fiber. The classifications are papermaking based, not science based.

This list is by no means exhaustive. It is merely a compilation of plants that various papermakers have used to make paper. I have not tested every fiber, but those who have assure me that these fibers yield a pulp that can be formed into sheets without adding other fibers. Since every papermaker has his or her own standards, processes, and aesthetics, I cannot guarantee the quality or yield of each plant. This list is meant merely to get you started and to serve as a guide. See How to Find Papermaking Plants and consult field guides to research other plant fibers.

Once you choose a plant, you can find a recipe in chapter 5 that uses a plant in the same category; use this recipe as a guide. For example, you can process wheat straw, which is found under Grass, Sedge, and Rush Fibers, by using the recipe

for mugwort paper. Or you can process elm, found under Woody Bast Fibers, with the recipe for paper mulberry paper. Please note that due to the fact that there are so many ways to process plant fibers and so many variables in each step of the process, the recipes are not guaranteed to work for every plant. As you process various fibers, you will observe similarities and differences about various types of plants. These will enable you to decide for yourself how to process them.

Woody Bast Fibers

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Banyan, Chinese	*Ficus retusa*	Moraceae
Birch, paper	*Betula papyrifera*	Betulaceae
Blackberry vines	*many varieties*	Rosaceae
Breadfruit	*Artocarpus altilis*	Moraceae
Cedar, western red	*Thuja plicata*	Cupressaceae
Daphne	*Daphne bholua*	Thymelaeaceae
Dewberry	*Rubus flagellaris*	Rosaceae
Elm, American	*Ulmus americana*	Ulmaceae
Elm, Siberian	*Ulmus pumila*	Ulmaceae
Elm, slippery	*Ulmus rubra*	Ulmaceae

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Euonymus, winged	*Euonymus alata*	Celastraceae
Fig	*Ficus benghalensis*	Moraceae
Gampi	*Wikstroemia retusa*	Thymelaeaceae
Grapevine	*Vitis vinifera*	Vitaceae
Hazelnut	*Corylus cornuta*	Betulaceae
Hibiscus tree, beach (a.k.a. *hau*)	*Hibiscus tiliaceus*	Malvaceae
Horse chestnut	*Aesculus hippocastanum*	Hippocastanaceae
Juniper	*Juniperus communis*	Cupressaceae
Kozo — see Mulberry, paper		
Kudzu	*Pueraria lobata*	Leguminosae
Leatherwood	*Dirca palustris*	Thymelaeaceae
Lime tree	*Tilia x europaea*	Tiliaceae
Linden, little-leaf	*Tilia cordata*	Tiliaceae
Mahoe, blue	*Hibiscus elatus*	Malvaceae

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Mitsumata	*Edgeworthia papyrifera*	Thymelaeaceae
Mulberry, black	*Morus nigra*	Moraceae
Mulberry, paper	*Broussonetia papyrifera*	Moraceae
Mulberry, white	*Morus alba*	Moraceae
Raspberry	*Rubus idaeus*	Rosaceae
Rose-of-Sharon	*Hibiscus syriacus*	Malvaceae
Sagebrush	*Artemisia tridentata*	Compositae
Scotch broom	*Cytisus scoparius*	Leguminosae
Screw pine	*Pandanus odoratissimus*	Pandanaceae
Willow, black	*Salix nigra*	Salicaceae
Willow, pussy	*Salix discolor*	Salicaceae
Willow, weeping	*Salix babylonica*	Salicaceae
Wisteria, Japanese	*Wisteria floribunda*	Leguminosae

Herbaceous Bast Fibers

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Dogbane/Indian hemp	*Apocynum cannabinum*	Apocynaceae
Flax	*Linum usitatissimum*	Linaceae
Hollyhock	*Alcea rosea*	Malvaceae
Jute	*Corchorus capsularis*	Tiliaceae
Kenaf	*Hibiscus cannabinus*	Malvaceae
Milkweed	*Asclepias syriaca, A. speciosa*	Asclepiadaceae
Okra	*Abelmoschus esculentus*	Malvaceae
Ramie	*Boehmeria nivea*	Urticaceae
Siberian iris	*Iris sibirica*	Iridaceae
Stinging nettle	*Urtica dioica*	Urticaceae
Sunn hemp	*Crotalaria juncea*	Leguminosae
Thistle	*Cirsium vulgare*	Compositae
Tobacco	*Nicotiana tabacum*	Solanaceae
True hemp	*Cannabis sativa*	Cannabaceae

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Velvetleaf/Indian mallow	*Abutilon theophrasti*	Malvaceae

Petiole Bast Fibers*

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Abaca	*Musa textilis*	Musaceae
Chinese banana	*Musa nana*	Musaceae
Dwarf Cavendish banana	*Musa acuminatai*	Musaceae
Tree-of-life/Ita palm	*Mauritia flexuosa*	Palmae

*Many of these require extensive processing

Leaf Fibers

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Agave	*Agava salmiana*	Agavaceae

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Canna lily	*Canna indica*	Cannaceae
Cattail	*Typha latifolia*	Typhaceae
Century plant	*Agave americana*	Agavaceae
Daffodil	*Narcissus pseudonarcissus*	Amaryllidaceae
Flax, New Zealand	*Phormium tenax*	Agavaceae
Ginkgo	*Ginkgo biloba*	Ginkgoaceae
Gladiolus	*Gladiolus spp.*	Iridaceae
Hosta/Plantain lily	*Hosta fortunei*	Liliaceae
Iris	*Iris spp.*	Iridaceae
Joshua tree	*Yucca brevifolia*	Agavaceae
Lily	*many varieties*	Liliaceae
Mother-in-law's tongue	*Sansevieria trifasciata*	Agavaceae
Pine, wild	*Tillandsia fasciculata*	Bromeliaceae
Pineapple	*Ananas comosus, A. bracteatus*	Bromeliaceae
Raffia	*Raphia farinifera*	Palmae

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Sisal hemp	*Agave sisalana*	Agavaceae
Yucca	*Yucca filamentosa*,*Y. elata*	Agavaceae

Grass, Sedge, and Rush Fibers

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Bagasse/Sugarcane	*Saccharum officinarum*	Gramineae
Bamboo	*Phyllostachys aurea*	Gramineae
Barley straw	*Hordeum vulgare*	Gramineae
Beach grass	*Ammophila arenaria*	Graminae
Cattail	*Typha latifolia*	Typhaceae
Corn husk and stalk	*Zea mays*	Gramineae
Crabgrass	*Digitaria sanguinalis*	Gramineae
Esparto grass	*Stipa tenacissima*	Gramineae

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Feather grass	*Phragmites australis*	Gramineae
Great bulrush/Tule	*Scirpus validus*	Cyperaceae
Job's-tears	*Coix lacryma-jobi*	Gramineae
Joe-Pye weed	*Eupatorium purpureum*	Compositae
Kangaroo grass	*Themeda Triandra*	Gramineae
Mugwort	*Artemisia vulgaris*	Compositae
Oat straw	*Arrhenatherum elatius*	Gramineae
Pampas grass	*Cortaderia selloana*	Gramineae
Papyrus/Umbrella plant	*Cyperus papyrus*	Cyperaceae
Reed canary grass	*Phalaris arundinacea*	Gramineae
Rice straw	*Oryza sativa*	Gramineae
Rush, common	*Juncus effusus*	Juncaceae
Spartina estuary grass	*Spartina alterniflora*	Gramineae

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Wheat straw	*Triticum aestivum*	Gramineae

Seed Fibers

COMMON NAME	BOTANICAL NAME	FAMILY NAME
Cotton	*Gossypium hirsutum*	Malvaceae
Milkweed	*Asclepias syriaca*	Asclepiadaceae
Silk-cotton tree	*Ceiba pentandra*	Bombacaceae
Thistle	*Cirsium vulgare*	Compositae

Fibers You Can Purchase*

RAW PLANT FIBER	PREPROCESSED FIBER
Flax *(Linum usitatissimum)*	Abaca *(Musa textilis)*
Gampi *(Wikstroemia retusa)*	Cotton linter

*From mail-order suppliers or local craft stores

RAW PLANT FIBER	PREPROCESSED FIBER
Kapok *(Ceiba pentandra)*	Esparto grass *(Stipa tenacissima)*
Kozo *(Broussonetia papyrifera)*	Flax *(Linum usitatissimum)*
Mitsumata *(Edgeworthia papyrifera)*	Hemp *(Cannabis sativa)*
Raffia *(Raphia farinifera)*	Jute *(Corchorus capsularis)*
Wheat straw *(Triticum aestivum)*	Sisal *(Agave sisalana)*

*From mail-order suppliers or local craft stores

Glossary

Abaca *(Musa textilis)*: A bast fiber from the leafstalk of a type of banana tree found in the Philippines and South America. The abaca fiber is located in the overlapping leaf stems in the trunk of the banana tree. Abaca fiber is imported to this country in the form of preprocessed sheet pulp, which can be further processed in a blender, whiz mixer, or hollander beater.

Alkali: A base substance that aids in the removal of noncellulose materials from a plant fiber when it's soaked or cooked in solution with the fiber. Common alkalis include soda ash (sodium carbonate, Na2CO3), washing soda, lime (calcium hydroxide, Ca(OH)2), and lye (sodium hydroxide, NaOH).

Ball mill: A machine, similar to a rock-polishing machine, used to beat pulp. Plant fibers are roughened and hydrated as they move between porcelain pebbles and the sides of a rotating jar.

Bast fiber: Fiber obtained from the inner bark (the phloem, which carries food and liquids) of plants, located between the outer black bark and the inner woody core. Bast fiber is found in both woody plants (trees, shrubs, vines) and herbaceous plants (soft, green-stemmed, nonwoody). Petiole bast fiber is found in the leafstalk of plants such as abaca and banana.

Bleeding: The spread of ink or color within a sheet of paper.

Calcium carbonate ($CaCO_3$): A powder that can be added to pulp at the end of the beating cycle as an alkaline reserve, which provides a buffer against future acid attack in the paper.

Cationic: Made up of positively charged ions.

Caustic: A substance that burns or destroys organic tissue by chemical action. It is used in cooking papermaking plants to break them down and eliminate the noncellulose components of the fiber. (See also Alkali.)

Cellulose: Long-chain polymers of sugars. These are the fundamental ingredients in paper. Plants that are fibrous have a high percentage of cellulose.

Chain lines: The visible lines impressed in sheets of paper made on a laid mould.

Cockling: The natural warping of paper as it dries. Cockling occurs when paper is air-dried or if there is not sufficient weight on top of the drying stack.

Cotton linter: Short fiber left on the cotton seed after ginning. It is removed from the plant and made into partially processed sheets of pulp.

Couching (pronounced cooch-ing): Transferring a freshly made sheet of paper from the mould surface onto a felt, a sheet of nonwoven polyester sheeting (pellon), or another surface.

Decortication: The process of removing the outer plant coverings, such as the bark, to obtain the fibrous part of a plant.

Deckle: The frame that is held on top of the mould during sheet formation to contain the loose pulp and determine the size, shape, and thickness of the sheet of paper.

Deckle box: A mould with a deep deckle, into which pulp is poured. This is commonly used to make thick sheets of paper, to mix pulps together, or if there is very little pulp.

Dye: A soluble, light-sensitive coloring substance that penetrates the fiber structure of paper and chemically attaches to the cellulose molecules. There are both synthetic and natural dyes; the latter usually require a mordant, a chemical that "fixes" a dye.

Felt: In traditional Western papermaking, a woven wool fabric with a smooth brushed surface onto which paper is couched. The absorbent qualities of the felt aid in releasing the sheet of paper from the mould. Although papermaking felts are woven, they have the texture and surface of nonwoven felt.

Fiber: Plant cells that impart elasticity, flexibility, and tensile strength in plants. Fiber is most often found in the structural parts of plants, such as stalks, stems, and trunks, although some plants have fibrous leaves, seedpods, or seed hairs.

Fibrils: The almost invisible, threadlike parts of individual fibers, which are roughened and loosened during the beating

process. During sheet formation, they aid in slowing drainage and in the interlocking and bonding of the fibers in a sheet of paper.

Formation aid: A viscous substance that slows drainage and allows time for sheet formation. The traditional Japanese formation aid is neri, made from the roots of the tororo plant. Synthetic formation aids come in powder form and include PNS, which can be used with pulp that has no other additives; and PMP, which can be used with pulp that has other additives, such as pigment or sizing. Formation agents can also be extracted from okra and hollyhock roots, as well as other plant materials.

Gampi *(Wikstroemia retusa)*: A member of the Thymelaeaceae family that grows in Asia, whose bast fiber is used for papermaking. Gampi is also the common name of Diplomurpha sikokiana, another member of the Thymelaeaceae family whose fiber can be used for papermaking.

Hollander beater: A machine that circulates papermaking fibers in a water-filled tub; it macerates, shortens, and hydrates the fibers as they pass between a roll with flat-ended blades and a bedplate. The Hollander beater was developed in Holland in the 1680s and is still manufactured for hand papermaking today.

Hydration: The swelling of fibers as they absorb water during beating.

Hydrogen bonding: The attraction between hydrogen atoms that holds both water and fiber molecules together, enabling a sheet to be formed and couched. As the water drains through the mould and is pressed out of the sheet, the cellulose molecules are pressed together, causing the hydrogen atoms to bond.

Kaolin: Also known as china clay; a fine white powder that can be added to pulp to make paper smooth and opaque.

Kapok *(Ceiba pentandra)*: A seed-hair fiber from the silk-cotton tree.

Kozo *(Broussonetia kazinoki* or *B. papyrifera)*: Two of the many members of the Moraceae family, commonly known as mulberry, whose inner bark is used in Japan for papermaking.

Laid: A mould surface created by a series of parallel wires (laid lines) sewn onto perpendicular wooden ribs that support the wires from below and prevent them from sagging under the weight of the pulp and water. Laid lines are visible in sheets of paper that are formed on a laid mould.

Light-fast: Color does not fade when exposed to light.

Lignin: The cementing material between the cellulose and the cell walls in plants, which can contribute to premature deterioration and discoloration in paper. Lignin can be dissolved by cooking the fiber in an alkali solution.

Mitsumata *(Edgeworthia papyrifera)*: A traditional papermaking bast fiber in Japan and a member of the Thymelaeaceae family.

Mordant: In dyeing, a substance used to bind a dye to a fiber.

Mould: The fundamental papermaking tool, upon which sheets of paper are formed. The mould's surface is a mesh screen held rigid by a frame that acts like a sieve as paper is formed, catching the fibers on top and allowing the water to drain through.

***Nagashi-zuki*:** The Japanese method of sheet formation. It involves dipping the mould into the vat several times. Bast fiber pulp, formation aid, and a flexible mould are used in the nagashi-zuki technique. Papers formed using this technique are traditionally couched without felts.

***Naginata* beater:** A Japanese beating machine used to tease bast fibers apart after stamping. It is similar to the Hollander beater except that it has curved knives instead of a bedplate and beater roll.

***Neri*:** See Formation aid.

Pellon: A spun or nonwoven polyester mesh often used as a couching surface in papermaking. Pellon is sold in sewing supply stores and comes in many thicknesses. There are several other brands of nonwoven materials similar to pellon.

pH: A term used to describe the alkalinity or acidity of a substance on a number scale from 1 to 14. Seven represents a neutral state; lower numbers indicate increasing acidity and higher numbers increasing alkalinity.

Pigment: An insoluble, finely ground coloring material that can be used to color pulp. Pigments do not naturally adhere to the fiber; they must be attached with a retention agent. Pigments useful for papermaking come in powder form or dispersed in water.

Post: A pile of freshly made sheets of paper that have not been pressed. In Western papermaking, the sheets are interleaved with felts; traditional Japanese posts are formed without felts.

Pulp: The wet mass of plant material that has been cooked and beaten from which paper is made.

Retention aid: A cationic substance that binds pigments to the surface of the fiber.

Retting: A fermenting process that occurs when plant fiber is left standing in water in a warm place, with frequent stirring, until bacterial action softens the fiber. Retting can also occur when fiber is left exposed to any form of moisture, including dew or rain.

Sizing: Any substance that makes a paper more water repellent. Internal sizings, such as Hercon 70, are added to pulp at the end of the beating cycle and are in the paper as it is

formed. External, or surface, sizing such as gelatin is applied to the surface of dry sheets.

Spurs: A group of sheets that are dried together.

***Sugeta*:** The Japanese papermaking mould, consisting of the su, which is a flexible and removable bamboo screen, and the keta, which is a hinged frame. The keta holds the su taut during sheet formation.

Vat: The container in which sheets of paper are dipped.

Whiz mixer: A motorized tool that rehydrates processed pulps, such as cotton linters and other sheet pulps.

Wove: A mould surface made up of woven screen, similar to a window screen. It is used to make paper with a consistent surface, without laid and chain lines.

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Journal focusing on paper arts, art stamping, and letter arts.

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There are numerous colleges, universities, and art centers that offer courses in papermaking. Check local directories to find course offerings in your area.

Papermaking Organizations

The Friends of Dard Hunter, Inc.

www.friendsofdardhunter.org

A national organization whose members are interested in all facets of papermaking; the group publishes a newletter and holds annual meetings.

Historic RittenhouseTown

215-438-5711

www.rittenhousetown.org

The birthplace of papermaking in America; provides tours and papermaking workshops.

International Assocation of Hand Papermakers and Paper Artists

www.iapma.info

An international organization whose members are interested in all facets of papermaking.

Robert C. Williams Paper Museum

Institute of Paper Science and Technology

404-894-7840

www.ipst.gatech.edu/amp

A papermaking museum that houses the information, materials, and tools that Dard Hunter collected during his

lifetime.

Contributors

I would like to thank the many papermakers whose contributions made this project possible. Those papermakers whose work appears in this book are credited below.

LOCATION	SAMPLE	CONTRIBUTOR
p. 35	fig papers	Kathy Crump (Five Mile Creek Papers: Stockton, CA)
p. 40 (left)	fiber-reactive–dyed papers	Katharine Nix (Australia)
p. 40 (right)	naturally dyed papers	Elaine Koretsky (Carriage House Paper: Brookline, MA)
p. 42	naturally dyed papers	Bridget O'Malley and Amanda Degener (Cave Paper: Minneapolis, MN)
p. 83	walnut-dyed papers	Bridget O'Malley and Amanda Degener (Cave Paper: Minneapolis, MN)
p. 84	flower petal papers	Kate's Paperie (New York, NY); lilac paper on far right © Langdell Paperworks

Keys to Chapter Openers

To find out what type of fiber was used for each of the papers in the chapter openers, see the chart below.

	PLANT/FIBER	PAPERMAKER
1	daylily and kozo	*
2	narcissus (board-dried)	Kathy Crump (Five Mile Creek Papers: Stockton, CA)
3	dracaena (unrinsed before beating)	Kathy Crump
4	large cattail	Marilyn Sward (Chicago, IL)
5	tobacco	Jean and Bryan Battey (Laughing Fish Studio: Bakersville, NC)
6	phragmites	*
7	potato (vegetable papyrus)	*
8	flax/straw (with indigo dye)	Marilyn Sward

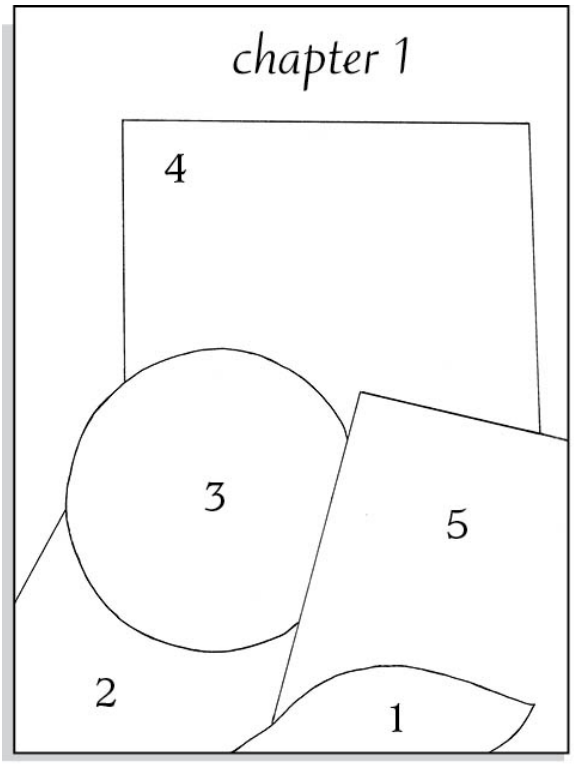
*made by the author

	PLANT/FIBER	PAPERMAKER
9	salago/gampi	Mary Leto (Nesconset, NY)
10	variety of plants gathered from a Maine meadow	Marilyn Sward
11	grated carrot (vegetable papyrus)	*
12	elm	*
13	dracaena (rinsed before beating)	Kathy Crump
14	mauritia (with a chiqui and pineapple mix)	Laura Anderson Barbata (New York, NY)
15	phragmites	*
16	zucchini (vegetable papyrus)	*
17	banana (with bits of bamboo)	Laura Anderson Barbata
18	red pepper (vegetable papyrus)	*

*made by the author

	PLANT/FIBER	PAPERMAKER
19	Joshua-tree leaf	M. L. Nutting (Delevan, NY)
20	daylily	A. Peterson (LaPorte, IN)
21	tapa cloth	Robbin Ami Silverberg (Brooklyn, NY)
22	Mauritia flexuosa	Laura Anderson Barbata
23	manila hemp (dyed with indigo)	Elaine Koretsky (Carriage House Papers: Brooklyn, NY)
24	giant bluestem grass	Marilyn Sward
25	gampi (dyed with safflower)	Elaine Koretsky

*made by the author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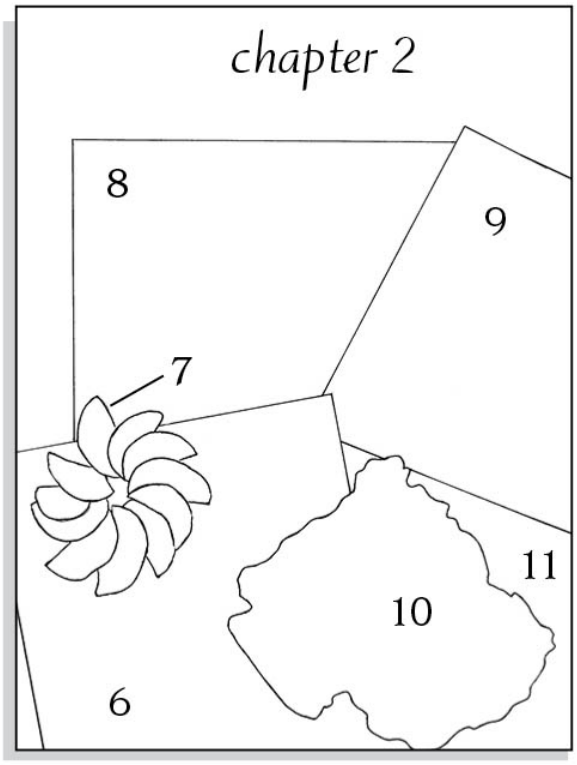
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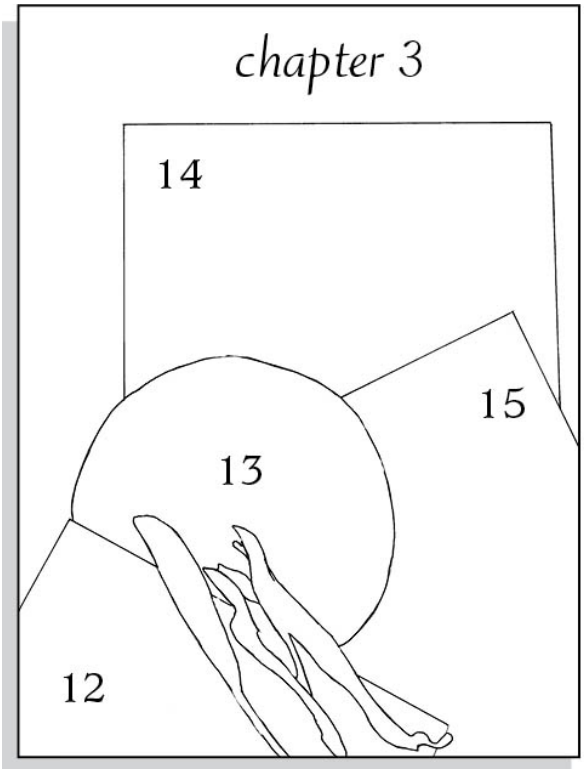
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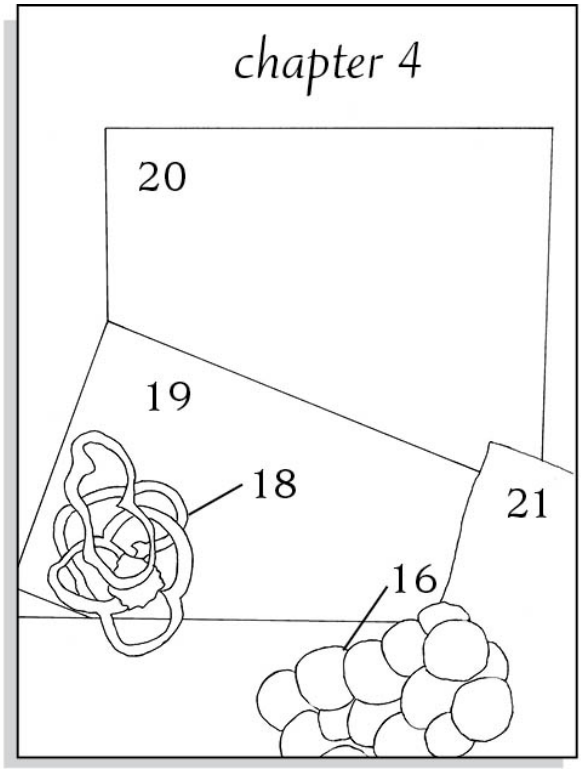
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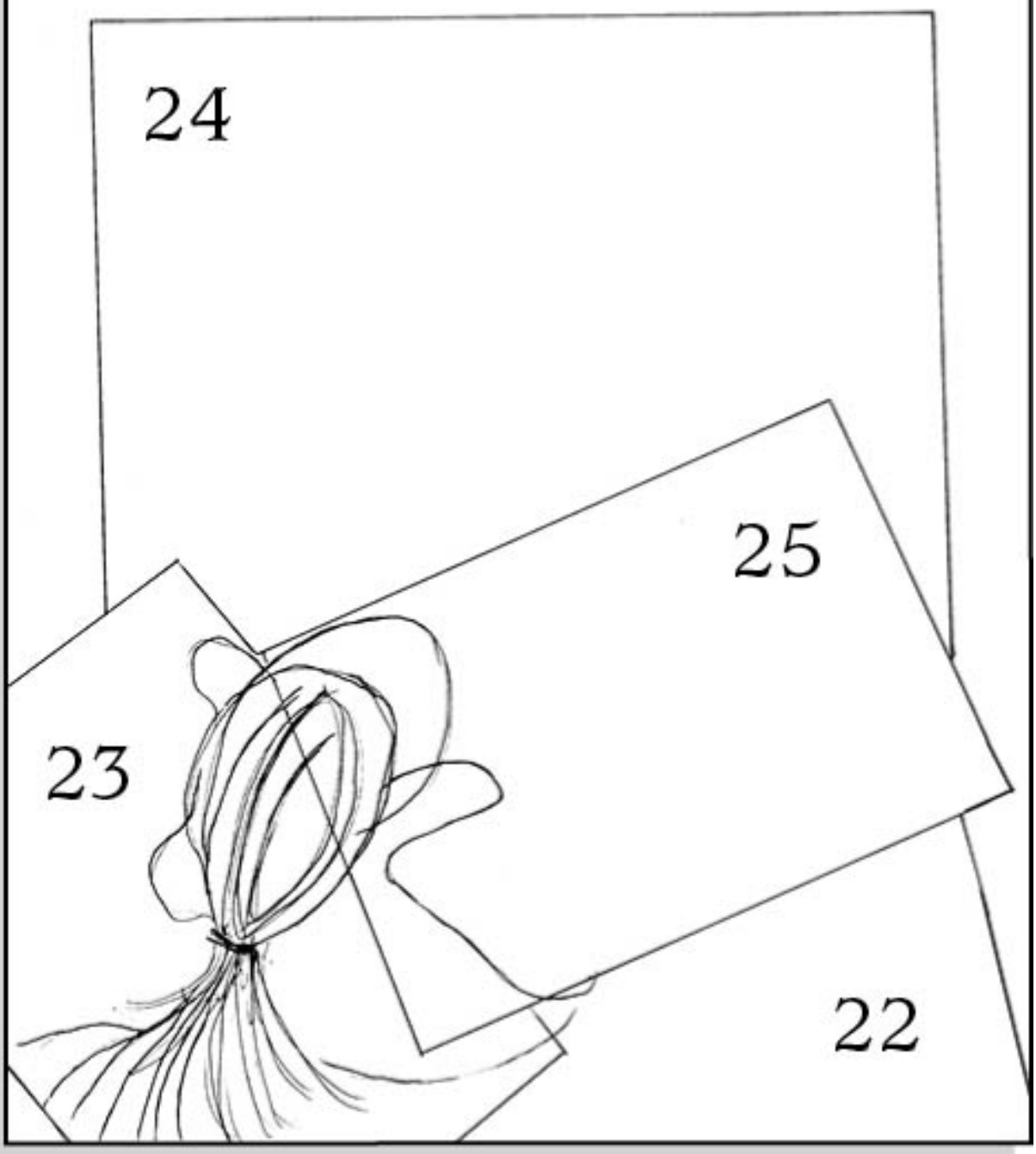

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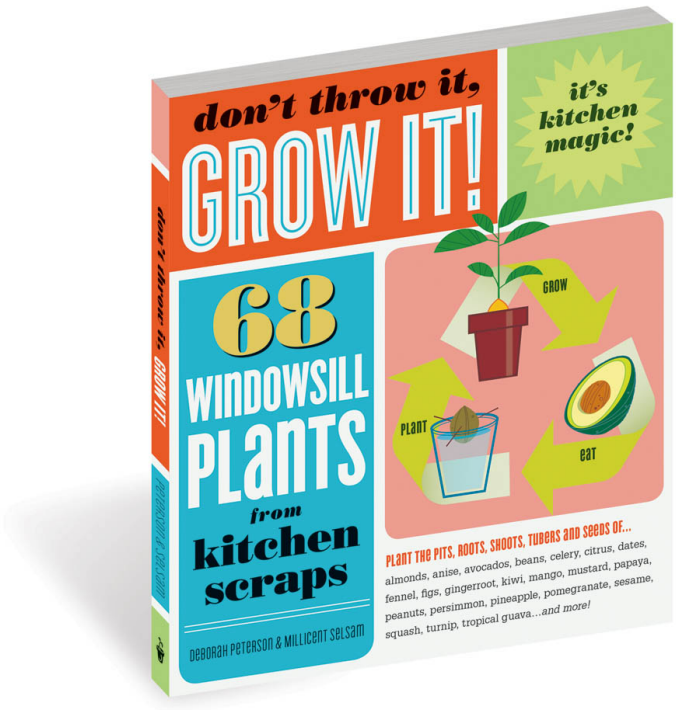
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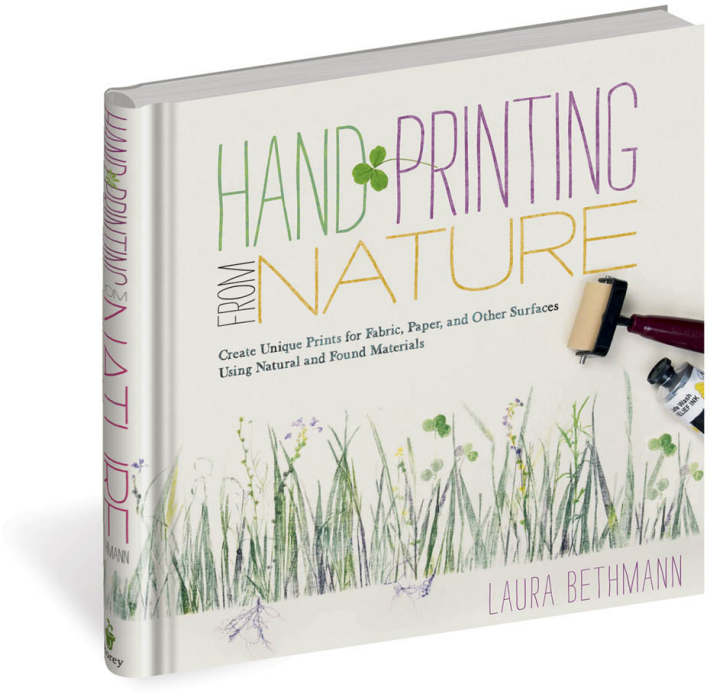
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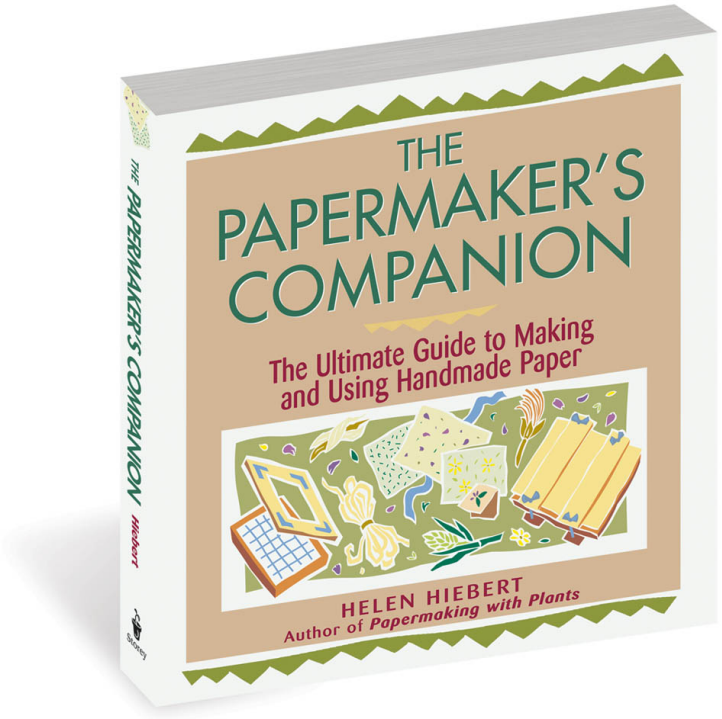
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